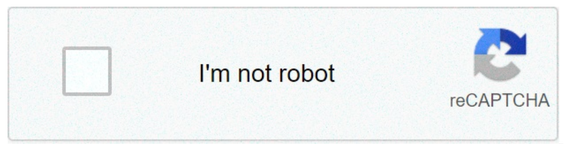

Continue

The dissociation constant for acetic acid and hcn at 25 degree celsius

SEPARATION PROCESS 1. In binary distillation, the separation of the components is easier if the relative volatility (α) is ______. a. α >>1 b. α < a. b. c. d. 0.532 0.83 0.425 0.18 7. In vacuum distillation, substance boils at ____. a. Its exact temperature b. Temperature slightly above its normal boiling point c. A temperature below its normal boiling point d. Under high pressure 8. Calculate the vapor pressure of a solution of 74g benzene in 48.8g toluene at 25 degC. a. 9.5 kPa b. 8.5 kPa c. 6.5 kPa d. 10.5 kPa 9. Calculate the relative volatility of the above solution. a. 4.02 b. 3.35 c. 6.9 d. 11.16 10. The estimated minimum number of stages for a binary distillation system with relative volatility of 2.35, having the lighter component at 0.98 in the distillate and 0.045 in the bottoms is _____. a. 9 b. 6 c. 7 d. 5 11. A filtration is carried out for 10 minutes at a constant rate in a leaf filter and thereafter it is continued at constant pressure. This pressure is attained at the end of the constant rate period. If one quarter of the total volume of the filtrate is collected during the constant rate period, what is the total filtration rate time? Assume the cake is incompressible and the filter medium resistance is negligible. a. 80 min b. 85 min c. 95 min d. 60 min 12. What is the fraction of the volume of voids over the total volume of the filter cake? 103 a. b. c. d. Permeability Filterability Sedimentation factor Porosity 13. Volume of the filtrate collected is 1 gal when the filtration rate is 1.5gpm and it is 5 gal when the filtration rate is 0.6gpm. Calculate the volume collected when the filtration rate is 0.55 gpm. Assume constant-pressure filtration. a. 3.67 b. 4.22 c. 5.59 d. 5.18 14. In the problem above, what is the total volume of the filtrate collected in 15 min? a. 4.45 b. 6.96 c. 10.85 d. 5.73 15. A plate and frame press delivers 50 liters of filtrate in an hour at constant pressure of 50 psig. The washing time using 50 L of wash water is _____. a. 1h b. 2.5h c. 4h d. 3h 16. Calculate the sphericity of a cylinder of diameter 1cmand height 3 cm. a. 0.779 b. 0.705 c. 0.755 d. 0.80 17. Find the sphericity of a cube of Vp=a3, Ap= 6a2 and c= a3. a. 0.790 b. 0.830 c. 0.853 d. 0.806 18. Which of the following is not an example of adsorption? a. Recovery and separation of pharmaceuticals b. Purification and recovery processes for gases and liquids c. Activated carbon-based applications d. Nitrogen from air by PSA using carbon molecular sieve 104 19. What is false about sedimentation of particles in a concentrated suspension? a. If a significant size range of particles is present, the large particles are settling to a suspension of smaller ones so that the effective density and viscosity of the fluid are increased. b. The upward velocity of the fluid displaced during settling is appreciable in a concentrated suspension. c. The apparent settling velocity is more than the actual velocity to the fluid. d. The velocity gradients in the fluid close to the particles are increased as a result of the change in the area and shape of the flow spaces. 20. Square plates with 0.0123 cm thickness and 0.0645 square cm are randomly falling through a liquid with a density of 55 lb/ft3 with a μ=15 centipoise. The SG of plates is 3.0, what is its settling velocity? a. 5.5cm/s b. 7.2 cm/s c. 3.9 cm/s d. 6.8 cm/s 21. How many "g" can be obtained in a centrifuge which can spin a liquid at 2000 rev/min at a maximum radius of 10 cm? a. 440 b. 450 c. 460 d. 470 22. A particle "A" of diameter 10 microns settles in an oil of SG 0.9 and viscosity of 10 poise under Stokes Law. A particle "B" with diameter 20 microns settling in the same oil will have a settling velocity of _____. a. Same as that of A b. ¼ as that of A c. Twice as that of A d. Four times as that of A 23. The US Standard Sieve series is equivalent to a 24 mesh Tyler Standard is _____ microns. a. 600 b. 100 c. 805 d. 707 24. A random handful of silica particles ranging in size from 28 mesh to 200 mesh is thrown to a very deep body of water (without tides or turbulence). 105 Data: Viscosity of water= 0.01 poise mesh= 0.0589 cm 3 Density of silica= 2.65 g/cm 200 mesh= 0.0074 cm The distance between the largest and the smallest particles after 10 min is _____. a. 4700 cm b. 4900 cm c. 5000 cm d. 4000 cm 25. An available crusher has been accepting hard rock with a volume surface mean diameter of 0.069 m and providing a product with a surface mean diameter of 5x10 3 m. The power required for crushing 10000 kg/h of this specified rock is 6.35 kW. Assume that the mechanical efficiency of the unit will remain unchanged. The power consumption if the capacity were reduced to 9000 kg/h with the same feed characteristics but with a reduction in the volume surface mean diameter of the product is 4 x10-3 m. a. 7.35 kW b. 7.00 kW c. 6.64 kW d. 8.64 kW 26. What will be the power required for the same feed at 100 tons/hr to be crushed to a product such that 80% is to passed through a 1.6 mm screen? a. 280 kW b. 260 kW c. 270 kW d. 290 kW 27. For low-porosity cakes, if the fraction of solute remaining is 0.3, the corresponding wash ratio is _____. a. 1.90 b. 0.75 c. 0.98 d. None 28. What filter media should be used when high resistance to oxidizing agents and high breaking tenacity are both required? a. Fluorocarbon b. Nylon c. Glass d. Acetate 29. Separation process depends on the differences in a particular property of the components of the mixture for fractional distillation, it is the difference in 1) _____ 106 for gas absorption, it is the difference in the 2) _____ in a solubility adsorbent and for liquid-liquid extraction it is based on the 3) _____ of a particular component in an immiscible solvent. a. 1) volatility 2) solubility 3) solubility b. 1) selectivity 2) diffusivity 3) volatility c. 1) volatility 2) diffusivity 3) solubility d. 1) selectivity 2) volatility 3) solubility 30. Calculate the equilibrium composition of the liquid and the vapour phases for the mixture of methyl alcohol in water at a temperature of 50 C and under a pressure of 40 kPa. Assume that both the liquid and the vapour behave ideally. At 50 C, the vapour pressure of methyl alcohol is 53.32 kPa and that of water is 12.33 kPa. a. Liquid 65.5% methyl alcohol; Vapour 85.95% methyl alcohol b. Liquid 67.5% methyl alcohol; Vapour 89.98% methyl alcohol c. Liquid 57.5% methyl alcohol; Vapour 79.80% methyl alcohol d. Liquid 47.5% methyl alcohol; Vapour 69.16% methyl alcohol 107 ANSWER KEY Separation Process 1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 108 A. α >>1 C. -1.5 A. Increases D. A total condenser is used D. 98oC A. 0.532 C. A temperature below its normal boiling point A. 9.5 kPa B. 3.35 A. 9 B. 85 min D. Porosity C. 5.59 B. 6.96 C. 4h A. 0.779 D. 0.806 A. Recovery and separation of pharmaceuticals C. The apparent settling velocity is more than the actual velocity to the fluid B. 7.2 cm/s B. 450 D. Four times as that of A D. 707 A. 4700 cm C. 6.64 kW A. 280 kW B. 0.75 C. Glass A. 1) volatility 2) solubility 3) solubility B. Liquid 67.5% methyl alcohol; Vapour 89.98% methyl alcohol SOLUTIONS 2. y = mx + b q 1 y=− x+ xF 1−q 1−q q 0.6 m = − 1−q = − 1−0.6 m = −1.5 Answer: -1.5 5. mol fraction benzene = 1 − 0.682 = 0.318 98 Answer: 98 degC 6. 109 Answer: 0.532 0.532 8. 74 g mol C6H6 = 78.1134 mol C8H10 = g mol = 0.94734 mol 48.8 g 92.1402 g mol mole fraction C6H6 = = 0.52963 mol 0.94734 0.94734+0.52963 0.52963 mole fraction C8H10 = = 0.6414 0.94734+0.52963 = 0.3586 Ptotal = ((P°)(x))C6H6 + ((P°)(x))C8H10 Ptotal = 95.1(0.6414) + (28.4)(0.3586) Ptotal = 71.2torr = 9492.5526 Pa = 9.5 kPa Answer: 9.5 kPa 9. (AB) = PA xB ( ) xA PB PA = xA (PA°) = (0.6414)(95.1) = 60.9971 torr PB = xB (PB °) = (0.3586)(28.4) = 10.1842 torr (AB) = 60.9971 0.6414 0.3586 (10.1842) (AB) = 3.3486 Answer: 3.3486 10. N= N= X X log(LD)(LB) XHD XHB log() log(0.98 1−0.045)( ) 1−0.98 0.045 log(2.35) N = 8.1306 = 9 stages Answer: 9 stages 110 11. dQ dV = 2V C + 2Vf C where C is a function of DP and mean specific cake resistance (a).If filter medium resistance is negligible, then Vf = 0.Now the equation can be written in the form, dQ 2V 2V = = dV C C2 (dP) For constant rate filtration, dQ/dV = Constant = Q/V Given: Q = 10 min for V = 0.25 Vt Where Vt = total volume of filtrate (filtrate collected in constant rate operation and constant pressure operation) 2V 10 40 = = C2 (dP) 0.25 Vt Vt Constant Pressure filtration: dQ = 2 (VdV) 0.0125 Vt 2 Qt − 10 = 80 (Vt 2 − (0.25 Vt)2) Vt 2 Qt = 10 + 80 (0.9375 Vt 2) Vt 2 Total filtration time (Qt) = 10 + 75 = 85 minutes Answer: 85 minutes 13. V= 1 gal, r= 1.5 gpm rf = 1.5 = k 2(V+Vc) k 2(1+Vc) 3 + 3 Vc = k equation 1 V= 5 gal, r= 0.6 gpm 0.6 = k 2(5+Vc) 111 6 + 1.2 Vc = k Solve for Vc and k: 5 Vc = k=8 equation 2 = 1.67 gal 3 gal2 min V= ?, r= 0.55 gpm 8 0.55 = 2(V+1.67) V = 5.60 gal Answer: 5.60 gal 14. @ t= 15 minutes ɵ= V2 15 = + k V2 8 V= ?gal 2VcV + k 2(1.67)(V) 8 V = 6.96 gal Answer: 6.96 gal 15. 1 16. = 2 3 (6Vp)3 diameter= 1 cm Ap 1 height= 3 cm 2 3 (6(0.5)2(3))3 = 2(0.5)(3)+2(0.5)2 = 0.779 Answer: 0.779 1 17. = 2 3 (6Vp)3 Ap 1 = = Vp = a3 Ap = 6a2 2 3 (6a3)3 6a2 1 2 3 (6)3 6 = 0.8060 Answer: 0.806 21. Fc = 0.011 mrN 2 Fg = mg Fc = Fg 112 0.011 rN 2 g Fc = Fg Fc Fg 0.011 (0.1)(2000)2 9.81 = 450 Answer: 450 25. P = 0.3162E(T 6.35 10 1 √x1 = 0.3162E(− 1 √x2 1) T1= 10000 kg/hr= 10 tons/hr 1 √0.069 − √5x10=3) E = −0.1943 P T P 9 = 0.3162E(1 √x1 − 1 √x2) = 0.3162(−0.1943)((T2= 9000 kg/hr= 9 tons/hr 1 1 √0.069 − √4x10=3) P = 6.6380 kW Answer: 6.6380 kW 26. P = 0.3162E(T P 100 1 √x1 − 1 √x2) = 0.3162(−0.1943)(T= 100 tons/hr 1 √0.069 1 − √1.6x10−3) P = 130.2052 kW Answer: 130.2052 kW 30. Liquid: xA = xA = P−PB PA −PB 40−12.33 53.32−12.33 xA = 0.6750 xA = 0.6750 x 100 = 67.50% Vapour: yA = yA = xA PA P 0.675(53.32) 40 yA = 0.8998x 100 = 89.98% Answer: Liquid 67.50%, Vapour 89.98% 113 FLUID FLOW AND THERMODYNAMICS 1. An ideal fluid is one that is a. compressible c. incompressible and viscous b. incompressible d. compressible and inviscid 2. The requirement by which the pressure of the liquid at the suction of the pump must exceed the vapor pressure of the liquid to avoid cavitation of pump is a. Net Positive Suction Head c. Cavitational Limit c. Cavitation Head d. Suction Head 3. Orifice has the highest permanent pressure loss among all meters. Which of the following increases the pressure drop across an orifice for a given flow rate? a. Decrease in orifice flow area c. Both a and b b. Decrease in orifice thickness d. Neither a nor b 4. Which of the following fittings exhibits the highest pressure drop for the same flow conditions? a. 90-degree long radius elbow c. 45-degree standard elbow b. 90-degree standard elbow d. square-corner elbow 5. A dimensionless group that is used to analyze transport phenomena and shows the ratio of interial forces to gravitational forces a. Euler number b. Froude number c. Newton number d. Reynolds number 6. The laminar flow regime can be characterized by a. parabolic profile b. exponential profile c. flat profile d. hyperbolic profile 7. Hydraulic radius is the ratio of a. wetted perimeter to flow area c. flow area to wetted perimeter b. flow area to square of wetted perimeter d. square root of flow area to wetted perimeter 8. Which of the following factors does not contribute to the pressure drop in a pipeline 114 a. velocity of fluid c. length of pipe and number of bends b. size of pipe d. none of these 9. It is a non-newtonian fluid which shoes an apparent viscosity that decreases with increases rate of shear. Examples are solutions of high polymers, paper pulp, and mayonnaise. a. Thixotropic fluids b. dilatant fluids c. rheopectic fluids d. pseudoplastic fluids 10. Ninety-eight percent sulfuric acid (viscosity = 25 x 10 -3 Ns/m2, density = 1840kg/m3) is pumped at 1.25kg/s through a 25mm diameter pipe, 30m long, to a reservoir 12m higher than the feed point. Calculate the pressure drop in the pipeline. Use mild steel pipe as the pipe. a. 320kPa b.240kPa c. 480kPa d. 560kPa 11. Natural gas which is essentially methane is being pumped through a 1.016m ID wrought iron pipeline for a distance of 1.609 x 10 5 m at a rate of 2.077kmol/s. It can be assumed that the line is isothermal at 288.8K. The pressure P2 at the discharge end of the line is 170.3 x 10 3 Pa absolute. Calculate the pressure P1 at the inlet of the line. a. 694 x10 3 Pa c. 724 x 10 3 Pa b.680 x 10 3 Pa d. 433 x 10 3 Pa 12. The rate of flow of water in a 150mm diameter pipe is measured with a venturi meter with a 50mm diameter throat. When the pressure drop over the converging section is 121mm of water, the flow rate is 2.91kg/s. What is the coefficient for the converging cone of the meter at this flow rate? a. 0.895 b. 0.598 c. 0.859 d. 0.985 13. Water flows 10ft/s through a pipe 1000ft long with a diameter of 1in the inlet pressure P1 = 200psig, and the exit section is 100ft higher than the inlet. What is the exit pressure P2 if the friction head loss is 350ft? a. 15psig b. 5psig c. 8psig d. 1psig 14. Six thousand liters per second (6000L/s) of waer at 320K is pumped in a 40mm inside diameter pipe through a length of 150m in a horizontal direction and up through a vertical height of 10m. In the pipe there is a control valve which may be taken as equivalent to 200 pipe diameters and other pipe fittings equivalents to 60 115 pipe diameters. Also in the line there is a heat exchanger across which there is a loss in head of 1.5m of water. If the main pipe has a roughness of 0.0002m, what power must be delivered to the pump of the unit is 60% efficient? a. 218W b.128W c. 521W d. 512W 15. A centrifugal pump is to be used to extract water from a condenser in which the vacuum is 640mmHg. At the rated discharge, the net positive suction head must be at least 3 above the cavitation vapor pressure of 710mmHg vacuum. If losses in the suction pipe account for a head of 1.5m, what must be the least height of the liquid level in the condenser above the pump inlet? a. 3.55m b.5.33m c. 1.77m d. 7.17m 16. For an isothermal process the internal energy of a gas a. Increases c. remains unchanged b. decreases d. data insufficient can't be predicted 17. During Joule-Thomson expansion of gases a. enthalpy remains constant c. temperature remains constant b. entropy remains constant d. none of these 18. Which of the following is not a intensive property a. Volume b. Density c. Temperature d. Pressure 19. Entropy of an ideal gas depends upon its a. pressure b. temperature c. both (a) & (b) d. neither (a) nor (b) 20. Coefficient of Performance (COP) of refrigerator is the ratio of a. work required to refrigeration obtained b. refrigeration obtained to the work obtained c. lower to higher temperature d. higher to lower temperature 21. 21.Work in the amount of 12kJ is done on a closed system, and its internal energy decreases by 25kJ. How much heat is removed from the system? a. 12 kJ b. 20 kJ c. 13 kJ d. 37 kJ 22. An ideal gas with CV = (7/2)R enters a process at 300K and 2 bar and leaves the process at 600K and 9 bar. Calculate its entropy change. 116 a. 5.4 J/mol-K c. 10.4 J/mol-K b. 8.4 J/mol-K d. 13.4 J/mol-K 23. Calculate the work necessary to compress air in an insulated cylinder from a volume of 6 ft 3 to a volume of 1.2 ft 3. The initial temperature and pressure are 50°F and 30psia, respectively. a. -99BTU b. -44BTU c. -120BTU d. -75BTU 24. Saturated steam at 630K is throttled to a pressure of 15bar. What is the quality of the stea after the throttling process? a. 0.947 b. 0.856 c. 0.744 d. 0.687 25. Wet steam at 400K has an enthalpy of 39kJ/mol. What is the quality of the steam? a. 0.589 b. 0.655 c. 0.748 d. 0.875 26. Two Carnot engines operate in series between two reservoirs maintained at 600°F and 100°F respectively. The energy rejected by the first engine is input into the second engine. If the first engine's efficiency is 20% greater than the second engine's efficiency, calculate the intermediate temperature. a. 744°F b. 285°F c. 352°F d. 671°F 27. A refrigerator with a power consumption of 1.8KW has a refrigeration rate of 4KW. If heat is rejected from the condenser at 40°C, what is the lowest possible temperature that the refrigerator can maintain? a. -8.5°C b. -30.2°C c. -57.2°C d. -64.1°C 28. Nitrogen gas expands adiabatically from 9 bar and 100°C to 2 bar, at a flowrate of 100mol/s. If the turbine efficiency is 0.80, calculate the power output of the turbine. Assume that nitrogen is an ideal gas with Cp = (7/2)R. a. 504kW b.630kW c. 379kW d. 303kW 29. Nitrogen gas enters a nozzle at 1000kPa and 200°C with a negligible initial velocity and discharges at a pressure of 500kPa. Assuming isentropic expansion of the nitrogen in the nozzle, determine the exit velocity. Assume nitrogen to be ideal gas with Cp = (7/2)R. a. 225m/s b.940m/s c. 550m/s d. 420m/s 30. Water at 200°F is pumped from a storage tank at the rate of 50gpm. The motor for the pump supplies work at the rate of 2hp. The water goes through a heat exchanger, giving up heat at the rate of 40000BTU/min and is delivered to a second storage 117 tank at an elevation 50ft above the second tank. What is the temperature of water delivered to the second tank? a. 101.75°F b. 110.74°F c. 118.9°F d. 104.27°F ANSWER KEY Fluid Flow and Thermodynamics 1. D. Incompressible & Inviscid 2. A. Net Positive Suction Head 3. C. Both a & b 4. D. Square-corner elbow 5. B. Froude Number 6. A. Parabolic profile 7. C. Flow area to wetted perimeter 8. D. None of these 9. D. Pseudo plastic fluids 10. A. 320kPa 11. B. 680 x 10 ^ 3 Pa 12. D. 0.985 13. B. 5 psig 14. B. 128 W 15. A. 3.55m 16. C. remains unchanged 17. A. Enthalpy remains constant 18. A. Volume 19. C. both (a) & (b) 20. B. Refrigeration obtained to the work required 21. D. 37kJ 22. D. 13.4 J/mol-K 23. D. -75BTU 24. B. 0.856 25. C. 0.748 26. B. 285°F 27. B. -30.2°C 28. D. 303kW 29. D. 420 m/s 30. A. 101.75°F 118 SOLUTIONS 2fv²L 10. ΔP = Dv NRe = (0.025)2 = 4.91 x 10−4 m2 4 Area = Vol = D m 1.25kg/s = = 6.7934 x 10−4 m3 /s 1840 kg/m3 volume 6.7934 x 10−4 m3 /s Velocity = = = 1.38360m/s area 4.91 x 10−4 m2 NRe = f= Dv = 0.079 NRe 0.25 1.38360m kg)(1840 3) s m 25x 10−3 Pa−s (0.025)(= 0.079 2545.824 2fv²L 2(.0111)(ΔP = = D 0.25 = 2545.824 = .0111 kg 1.38360m)²(30m)(1840 3) s m = 93836.79 Pa 0.025m P = 93836.79 Pa + (9.81)(1840)(12m) = . 11. kmol 16 kg 2.077 s ( ) kmol = 40.99 G= 4 (1.016m)² NRe = DG 1.016 (40.99) = = 3820719.266 1.09 x 10−5 0.9 . 27(4.57x10−5 7)) = −4 log(+(1.016 3820719.266 √f 1 f = 2.8042 x 10−3 119 P1 2 − P2 2 = G 2 RT 4fL P1 (+ 2ln) MW D P2 P1 2 − (170.3 x 103)2 8.314(288.8) 4(2.8042 x 10−3)(1.609x105 (16/1000 1.016 P1 + 2ln) 170.3 x 103 = 40.992 P1 = , . 12. C = 0.98 is commonly used for NRe > 10,000 15.NPSH = P1−P2 g + Δz − hf P1 = 640 mmHg = 15998.6842 Pa P2 = 710 mmHg = 6666.1184 Pa 3m = 15998.6842 − 6666.1184 + Δz − 1.5 (999)(9.81) Δz = . 21. ΔU = Q − W −25 = 12 − W W = 37kJ T2 P1 22.ΔS = nCp ln T1 + nRln P2 ΔS = 9 600 2 (8.3145) ln + 8.3145ln 2 300 9 ΔS = . 120 23. Q = ΔU + W 0 = ΔU + W ΔU = −W −W = mCv ΔT T2 = T1 (V1 1.4−1) V2 T2 = 283.15 (0.17 1.4−1) 0.0340 T2 = 539.0196 K − W 0.717KJ KJ) (539.0196 − 283.15)K = −183.4585 =(= −. m kg − K kg 24. @ 630K = 5.10525 @ 15 bar Sf = 3.697023125 Sfg = 3.697023125 5.10525 = 3.697023125 + 3.697023125x X = 0.88 26. n1 = T1 − T2 W = T1 Q2 + W n2 = T2 − T3 W = T2 Q3 + W T1 − T2 = T2 − T3 600 − T2 = T2 − 100 T2 = 350 ∗ .80 = ⁰ 121 27. 4 40 = 1− 1.8 x x = -32.72 °C 28. T2 = T1 (P2 1.4−1) 1.4 P1 2 1.4−1 T2 = 373.15 ( ) 1.4 9 T2 = 242.8014 K ΔU = W = mCp ΔT 7 W = (100) ( ) (8.314)(373.15 − 242.8014) = 379301.3911 W = 379.301 KW 2 W = 379.301 ∗ .80 = . 29. H1 + V12 V22 = H2 + 2 2 V2 = √V12 + 2 1.4(R) (T1 − T2) 1.4 − 1 T2 = (200 + 273.15) (500 1.4−1) 1.4 1000 T2 = 388.1416 K R = 287 J/kg-K V2 = √0 + 2 1.4(287) (473.15 − 388.1416) 1.4 − 1 = / 122 30. Water @ 200F = 366.48 K Z150ft = 15.24m Density = 963.24 kg/m3 50 gpm = 3.15451 x 10 ^ -3 m3/s Mass flow rate = 3.15451 x 10−3 (963.24) = 3.0386 kg/s PUMP : 2hp = 1492Watts W = 1492 W (1) = 491.02J /kg 3.0386 kg/s HEAT EXCHANGER: -40000 BTU/min = -703370.8 Watts Q = −703370.8W (1 kg 3.0386 s) = −231478.5757 J/kg H1 @ 366.48K = 390 x 10 ^ 3 J/kg V22 − V12 H2 − H1 + gΔz + =Q−W 2 H2 − 390 x 103 + (9.81)(15.24) + 0 = −231478.5757 − (−491.02) H2 = 158862.9256 J 158.8629KJ = = 2.8627 KJ/mol kg kg By interpolation Enthaply Temp. 2.7810 310K 3.5340 320K T = 311.08 K = 100.274°F 123 LEACHING AND LIQUID-LIQUID EXTRACTION 1. A counter current multiple contact extraction system is to treat 50 tons/hr of wet beets with fresh water as the solvent. The beets have the following analysis: Components Mass fraction water 0.48 pulp 0.40 sugar 0.12 The strong solution leaving the system is to contain 0.15 mass fraction sugar, 97% of the sugar in the sliced beets is to be recovered. Determine the number of extraction cells required, assuming equilibrium between the underflow and overflow in each cell. If each ton of dry pulp retains 3 tons of solution. If each ton of dry pulp retains 3 tons of water. 2. The oreobody of the Union Miniere du Haaut-Katanga in the Belgian Congo is composed of malachite (CuCO3 Cu(OH)2) and gangue. Copper is extracted by crushing the ore to – 20 mash., agitating with a diute solution of sulfuric acid, followed by multiple-contact counter current washing to wash the gangue free of the copper-bearing solution. The rich solution from the washing system is treated for removal of dissolved iron and aluminum and then sent to the electroytic cells for precipitation of the copper. The dilute acid solution from the cells is recycled to the agitators for treatment of more raw ore. The counter current washing operation uses Dorr thickeners for the recovery of the rrich solution. The slurry from the agitators, with the copper in the solution as copper sulphate, is fed to the thickeners at the rate of 300 tons per hour. According to operating records, the underflow from each thickener retains 1.22 tons of solution per ton of gangue,and the streams have the following compositions in mass percent. 124 Feed to Thickener, % Strong Solution % Underflow Leaving System mass % CuSO4 6.10 6.69 1.0 Gangue 14.92 --- 99.0 Water 78.98 93.31 99.0 Determine the number of equilibrium stages. 3. Halibut oil is extracted from granulated halibut livers in a countercurrent multibatch arrangement using ether as the solvent. The solids charge contains 0.35 kg oil/kg exhausted livers and it is desired to obtain a 90 per cent oil recovery. a). How many theoretical stages are required if 50 kg ether is used/100 kg untreated solids? The entrainment data are: Concentration of overflow(kg oil/kg solution) 0 0.1 0.2 0.3 0.4 0.5 0.6 0.670 Entrainment (kg solution/kg extracted livers) 0.28 0.34 0.40 0.47 0.55 0.66 0.80 0.96 b. The mass of ether in the overflow c. The mass of liver fed per 100 kg of untreated solids 4. 4. Coconut oil is to be produced from dry copra in two stages. First, through expellers to squeeze out part of the coconut oil and then through a countercurrent multistage extraction process. After expelling, the dry copra cake contains 20% residual oil. In the extraction operation, 90% of the residual oil in the expeller cake is extracted as a solution containing 50% by weights oil. If fresh solvent is used and one kg of solution with every two kg of insoluble cake is removed with the underflow, how many number of ideal stage is required? 5. 5. A plant produces 8640 tonnes per day (100 kg/s) of titanium dioxide pigment which must be 99.9 per cent pure when dried. The pigment is produced by precipitation and the material, as prepared, is contaminated with 1 kg of salt solution, containing 0.55 kg of salt/kg of pigment. The material is washed countercurrently with water in a number of thickeners arranged in series. How many thickeners will be required if water is added at the rate of 17,400 tonnes per day (200 kg/s) and the solid discharged from each thickener removes 0.5 kg of solvent/kg of pigment? What will be the required number of thickeners if the amount of solution removed in association with the pigment varies with the concentration of the solution in the thickener, as follows? The concentrated wash liquor is mixed with the material fed to the first thickener. Concentration of solution Amount of solution removed (kg solute/kg solution) (kg solution/kg pigment) 125 0 0.1 0.2 0.3 0.4 0.5 0.30 0.32 0.34 0.36 0.38 0.40 6. In a pilot scale test using a vessel 1 m3 in volume, a solute was leached from an inert solid and the water was 75 per cent saturated in 100 s. If, in a full-scale unit, 500 kg of the inert solid containing, as before, 28 per cent by mass of the watersoluble component, is agitated with 100 m3 of water, how long will it take for all the solute to dissolve, assuming conditions are equivalent to those in the pilot scale vessel? Water is saturated with the solute at a concentration of 2.5 kg/m3. 7. Seeds, containing 20 per cent by mass of oil, are extracted in a countercurrent plant, and 90 percent of the oil is recovered in a solution containing 50 per cent by mass of oil. If the seeds are extracted with fresh solvent and 1 kg of solution is removed in the underflow in association with every 2 kg of insoluble matter, a). what is the mass fraction of insoluble material in the underflow ? b). how many ideal stages are required? 8. It is desired to reduce the concentration of pyridine in 500 kg of aqueous solution from 20% w to 5% w in a single batch extraction using chloro-benzene as solvent. Equilibrium compositions (end points of the tie line) in terms of weight percent of pyridine – water-chlorobenzene are (5, 95, 0) and (11, 0, 80) a. The amount of raffinate is ___. b. The amount of pure solvent required for the extractions is ____. 9. It is desired to extract acetone from a feed containing acetone and water, using chloroform as the solvent, in two cross current extraction stage as shown below. Assume that water and chloroform are immiscible. The ffg. are given for the process. The feed is equimolar mixture of acetone and water. The quantities of chloroform used in 2 stages are equal. 60mole % of the acetone in the feed is extracted in stage I. The extract and raffinate phases existing from each stage are in equilibrium. The equilibrium relation for the distribution of acetone is given by: (moles of acetone in water rich phase)/ (moles of water in water rich phase) = 2.0 x (moles of acetone in chloroform rich phase)/ (moles of chloroform in chloroform rich phase) a. Determine the quantity of chloroform used in each per mole of feed. b. Determine the mole fraction of acetone (product) after stage I 126 c. Determine the mole fraction of acetone (final product) 10. A feed containing a solute is contacted with a solvent (S) in an ideal stage as shown in the diagram below. Only the solute transfers into the solvent. The flow rates of all the streams are shown on a solute free basis and indicated by the subscript S. The compositions of the streams are expressed on a mole ratio basis. The extract leaving the contactor is divided into two equal parts, one part collected as the product (P) and the other stream is recycled to join the solvent. The equilibrium relationship is Y* = 2X. a. The product flow rate (Ps) b. The composition (Y out) c. The composition of raffinate (X out) ANSWER KEY Leaching and Liquid-Liquid Extraction 1.) a.) 16 extraction cells b.) 17 extraction cells 2.) 4 stages 3.) a.) 3 stages b.) 27.33 kg ether 4.) 5 stages 5.) 4.36 x 5 thickeners 6.) 98.70 mins 7.) a.) 0.66 inert b.) 5 stages 8.) 421.05 kg raffinate 638.76 kg pure solvent 9.) 1.50 mol Chloroform 0.29 acetone 10.) a.) 100 mol/s b.) 0.22 c.) 0.11 127 SOLUTIONS: 1. Required: No. of Exraction Cells 97 % r 0.15 sugar V2 Y2 Water Vn+1 Yn+1 Lo = L1 X1 Ln Xn = 0.03x1 50 tons/hr 0.048 water 0.40 pulp 0.12 sugar Ln = Lsoln = 50(0.4 pulp) ∗ Xn = 3 ton soln tons = 60 dry pulp hr 0.03(50 (0.12 sugar)) = 0.003 60 Y1 = 0.15 = 0.97 (0.12 (50)) V1 V1 = 38.8 tons /hr Solution Balance: Lo + Vn+1 = Ln + V1 (50-0.4(50)) + Vn+1 = 60 + 38.8 Vn+1 = 68.8 tons/hr X1 = Y1 = 0.15 Vn+1 (Y2 – Yn+1) = Ln (X1-Xn) 68.8 (Y2-0) = 60 (0.15-0.003) Y2 = 0.1282 128 a. 0.15 − 0.1292 0.003 N= + 1 = 15.49 0.15 − 0.003 log 0.1282 log N = 16 extraction cells b. If R = 3 tons water dry pulp Ln = 60 tons/ hr V1 = 38.8 tons/hr Solution Balance: 50 (0.6) + Vn+1 = 60 +32.98 Vn+1 = 62.98 X1 = 0.1764 , Xn = 0.003 Y2 = N= 60 (0.1764 − 0.003) = 0.150888 62.98 0.1764 − 0.150888 0.003 +1 0.1764 − 0.003 log 0.150888 log N = 16.39 = 17 extraction cells 2. Required: Number of stages Vo 6.69% CuSO4 93.31 % Water Vn Water Lo = 300 tons/ hr 6.10% CuSo4 14.92 Gangue 78.98% Water 129 Ln 1% CuSO4 99% Water + Gangue R = 1.22 tons of solution / tons gangue In Lo: Gangue = 0.1492 (300 tons/hr) = 44.76 tons/ hr CuSO4 + Water at Ln = 1.22 tons of sol'n / tons gangue (44.76 tons / hr) = 54.6072 tons of sol'n / hr CuSO4 Balance: (0.0610) (300 tons/hr) = 0.01 Ln + 0.01 Ln + 0.0669Vo Water Balance: (0.7898) (300 tons /hr) = WaterLn + 0.9331Vo – Vn Vn = 58.0567 Gangue Balance: 0.1492 (300 tons/hr) = GangueLn GangueLn = 44.76 tons/hr In Ln: 0.99 = GangueLn + WaterLn Gangue Ln + WaterLn + CuSO4Ln 0.99 = 44.76 + 54.6072 − CuSO4Ln 44.76 + 54.6072 − CuSO4Ln + CuSO4Ln CuSO4Ln = 0.993672 tons/hr = 0.01Ln ; Ln = 99.33672 tons/hr CuSO4 Balance : 0.0610 (300 tons/hr) = 0.993672 tons/hr + 0.0669Vo Vo = 258.6895 tons/hr Ya = 0.993672 / 54.6072 = 0.0182 Yb* = (54.6072 / 58.0567) (0.0669 − 0.0182)) = 0.0458 0.0669 − 0.0458 0.0182 N−1 = 0.0669 − 0.0182 ln 0.0458 ln N = 3.41 = 4 stages 130 3. Required: Number of stages , mass of ether at overflow r = 90% Y1 23.33 kg oil 50-e kg ether 50 = Vn+1 Yn+1 = 0 Y2 100 kg 74 kg live 26 kg oil X1 Ln Yn e(ether) Solution: Ratio Overflow Concentration Entrainment Oil Ether 0 0.28 0 0.280 0.1 0.34 0.034 0.306 0.2 0.40 0.080 0.320 0.3 0.47 0.141 0.329 0.4 0.55 0.220 0.330 0.5 0.66 0.330 0.330 0.6 0.80 0.480 0.320 0.670 0.96 0.643 0.317 Basis: 100 kg untreated solids Mass of livers fed (1+0.35) = 100 M livers fed = 74.0741 kg exhausted liver 100 – 74.0741 = 25.9259 kg oil 131 b. M ether underflow = 0.306 kg ether / kg ex liver (74.0741 kg ex liver) = 26.67 kg ether M ether overflow = 50 – 22.67 = 27.33 kg ether X1 = Y1 = 23.33 kg oil / 27.33 kg ether = 0.8536 Xn = 2.5926 kg oil / 22. 67 kg ether underflow = 0.1144 Ln (X1 – Xn) = Vn+1 (Y2 – Yn+1) 22.67 (0.8536 – 0.1144) = 50(Y2 – 0) Y2 = 0.3352 a. No. of Stages 0.8536 − 0.3352 0.1144 − 0 N−1 = 0.8536 − 0.1144 log 0.3352 − 0 log N = 2.91 = 3 stages 4. Required : Number of Stages V1 y1=0.50 y2 Lo Xo = 0.2 x1 Assuming 2 kg solids At Ln: Msolution = 1kg sol'n / 2 kg solids (2 kg solids) = 1kg solution y1 = x1 = 0.50 yn+1 = 0 Oil in Lo = 2 kg / 0.8 (0.2) = 0.5 kg Oil in Ln = 0.5 kg (0.1) = 0.05 kg 132 Vn+1 Yn+1 = 0 Ln 1 kg sol'n / kg solids Xn Oil in V1 = 0.5 kg -0.05kg = 0.45 kg V1 = 0.45 kg / 0.50 = 0.90 kg Overall Material Balance: Vn+1 + Lo = V1 + Ln Vn+1 + 0.50kg = 0.90kg + 1kg Vn+1 = 1.4 kg Xn = 0.05kg / 1 kg = 0.05 y2 = 1kg / 1.4kg (0.50 – 0.05) = 0.3214 0.50 − 0.3214 0.05 N−1= 0.50 − 0.05 ln 0.3214 ln N = 4.7833 = 5 stages 5. 54.9 kg salt Y2 Y1 200 kg s H2O Yn+1 100 100 kg s X1 TiO2 Xn removed = 0.5 kg solvent Y1=X1 = Xn = 0.1 50 54.9 195 kg salt kg pigment s TiO2 0.1 kg salt kg pigment REQD: No. of thickeners, N SOLN: H2O Bal: (45 + 200) = 50 + X X = 195 kg H2O 1 kg salt solution = 0.55 kg = 55 kg salt = 0.2815 = 0.002 50 (X1-Xn) = 200 (Y2-Yn+1) 133 50 (0.2815-0,002) = 200 (Y2-0) Y2 = 0.0699 0.2815−0.0699 0.002 0.2815−0.002 log 0.0699 log N= N = 4.36 x 5 thickeners 6. PILOT SCALE: Cs = 2.5 kg/m3 V = 1.0 m3 t = 100s C = 2.5 kg/m3 (0.75) = 1.875 kg/m3 Using Fick's Law of Diffusion C = Cs (1-e −(k′A⁄BV)t) 1.875 = 2.5 (1-e −(K′A⁄B) (100s)) 3 k′A = 0.013863 m ⁄s B FULL SCALE: Cs = 2.5 kg/m3 V = 100 m3 C = 0.28 (500g) 100m3 = 1.40 kg/m3 C = Cs 1-e −(K′A⁄B)t) 1.40 2.5 (1-e −(0.013863⁄100)t) t = 5922.10 s t = 98.70 mins 7. Y2 Un+1 Yn+1 N Lo 20% oil 80% inert 90% r 50% oil Y= 0.5 REQD: a. Xinert 134 Ln Xn X1 1kg soln 2kg insoluble b. Ideal Stages, N SOLN: Basis: 100g Lo 0.2 (100) kg oil (0.9) = moil V1 = 0.5 V1 V1 = 36 kg 1kg soln 0.80 (100) kg inert (2 kg inert) = 40 kg soln = Ln Solution Bal: 20 + Vn+1 = 40 + 36 Vn+1 = 56 kg 0.1 (20) = 0.05 40 X1 = Y1 = 0.5 Ln (X1-Yn) = Vn+1 (Y2-Yn+1) 40 (0.5-0.05) = 56 (Y2-0) Y2 = 0.3214 Xn = a. Xinert = 80 40 + 80 + 2 Xinert = 0.66 X1−Y2 b. N-1 = N= logXn−Yn+1 X1−Xn Y2−Yn+1 0.5−0.3214 log 0.05−0 0.5−0.05 log0.3214−0 log +1 N = 4.78 ≈ 5 stages 8. V1 11% pyridine 89% chlorobenzene Lo = 500 kg 20% pyridine 80% H2O Vo Pure chlorobenzene EXTRACTOR L1 5% pyridine 95% H2O OMB: Lo + Vo = L1 + V1 135 Pyridine Balance: 0.20 (500 kg) = 0.05 L1 + 0.11 V1 Chlorobenzene Balance: Vo = 0.89 V1 H2O Balance: 0.80 (500kg) = 0.95 L1 L1 = 421.05 kg (raffinate) Using Pyridine Balance: 0.20 (500kg) = 0.05 (421.0526 kg) + 0.11 V1 V1 = 717.7034 kg Using Chlorobenzene Balance: Vo = 0.89 V1 Vo = 0.89 (717.7034 kg) Vo = 638.76 kg pure solvent 9. chloroform S1 chloroform S2 H2O P2 P1 F = 1mol H2O 0.5mol 50% acetone E1 0.5mol H2O 0.5-0.3 = 50% H2O 0.2-x mol acetone 0.2 mol acetone E2 1.5 mol chloroform 60%x acetone feed xacetone = ? 0.6 (0.5) = 0.3 mol acetone REQUIRED: a. Amt chloroform, S b. mol acetone after stage 1 , Xacet1 c. mol acetone final pdt , Xacet2 SOL'N: 136 in feed, F: acetone = 0.5 mol H2O = 0.5 mol in E1: acetone = 0.6(0.5) = 0.3 mol acetone c. Using the relationship: mol acetoneH2O mol H2 O(H2O) 0.2 0.5 mol acetone(chloroform) = 2 mol chloroform (chloroform) =2 0.3 S S = 1.50 mol Chloroform in P1: acetone = 0.5 – 0.3 = 0.2 mol acetone H2O = 0.5 mol H2O 0.2 d. 0.5+0.2 = Xacet1 Xacet1 = 0.29 E2 = acetone + S2 S2 = 1.5 Acetone = 0.2-X P2 = acetone + H2O acetone = X H2O = 0.5 e. using the relationship: X =2 0.5 0.2−X 1.5 x = 0.08 mol acetone Xacet2 = 0.08 0.08+0.5 ; Xacet1 = 0.14 10. Feed (Fs) = 100 mol⁄s Xin = 0.3 EXTRACTOR Raffinate (R) Xout E Solvent (S) = 100 mol⁄s Yin = 0 Total Feed = . = 142.8571 Extracted Recycle A Product (P) Yout 137 OMB: 142.8571 + 100 = R + P Solute Balance: 0.3 (142.8571) = Xout R + Yout P P = 100/(1-2Xout) Using OMB (1): 242.8571 = R + 100/(1-2Xout) 242.8571-485.7142 Xout = R + 100 – 2R Xout 142.8571 - 485.7142 Xout = R (1-2Xout) R= 142.8571−485.7142 Xout 1−2 Xout Using Solute Balance (2): 42.8571 = R Xout + 2Xout (1-2Xout) 42.8571-85.7142 Xout = (R Xout -2RX2out + 200 Xout 42.8571-285.7142 Xout = R (Xout - X2out) R= 42.8571−285.7142 Xout Xout−X2 out Using 1 & 2: R=R 142.8571−485.7142 Xout 1−2 Xout = 42.8571−285.7142 Xout Xout−X2 out Xout = 0.11 ; Yout = 0.22 a. Ps = 100 1−2 (0.11) Ps = 100 mol/s b. Yout = 2Xout Yout = 2(0.11) Yout = 0.22 c. Xout = 0.11 138 (0.78) PHYSICS, STATICS, DYNAMICS, CHE LAWS & ETHICS 1. A projectile is fired with a horizontal velocity of 30 m/s from the top of a cliff 80 m high. How far from the foot of the cliff will it strike? a. 112m b. 230 m c. 121 m d. 151m 2. A 5.00 kg object is to be given an upward acceleration of 0.30 m/s2 by a rope pulling straight upward on it. What must be the tension in the rope? a. 65.4 N b. 45.2 N c. 50.5 N d. 38.7 N 3. An object is dropped from rest from a height of 49 meters. What is the speed of the object as it hits the ground? a. 35 m/s b. 31 m/s c. 28 m/s d. 19 m/s 4. An 8-gram bullet is fired horizontally into a 9-kg block of wood and sticks in it. The block, which is free to move, has velocity of 40 cm/s after impact. Find the initial velocity of the bullet. a. 450 m/s b. 350 m/s c. 220 m/s d. 510 m/s 5. An object travelling a circular path makes 1200 revolutions in 1 hour. If the radius of the path is 10 m, calculate the speed of the object. a. 19 m/s b. 21 m/s c. 20 m/s d. 22 m/s 6. A stone is thrown straight upward and it rises to a height of 20 m. with hat speed was it thrown? a. 12.6 m/s b. 19.8 m/s c. 17.7 m/s d. 23.8 m/s 7. A train is travelling with a speed of 60 mi/hr is brought to an emergency stop in 2000 f. what is the time required for the train to stop? a. 50 s b. 35 s c. 46 s d. 60 s 8. A 0.25 hp motor is used to lift a load at the rate of 5.00 cm/s. how great a load can lift at this constant speed? a. 381 kg b. 350 kg c. 421 kg d. 400 kg 9. By the use of the pulley, a man raises a load 120 lb to a height of 40 ft in 65 seconds. Find the average horsepower required. a. 0.18 hp b. 0.19 hp c. 0.13 hp d. 0.04 hp 10. A certain cable is suspended between two supports at the same elevation and 50 m apart. The load is 50 N/m horizontal length including the weight of the cable. If the sag of the cable is 3m, calculate the total length of the cable. a. 40.12 m b. 25.40 m c. 50.48 m d. 60.24 m 139 11. A 10-kg block of copper at 60oC is placed in contact with the identical 10-kg block of copper at 20oC. What is the equilibrium temperature of both blocks? (for copper c=0.24 kJ/kg-oC) a. 55 deg C b. 45 deg C c. 50 deg C d. 40 deg C 12. A certain 1200-kg car can accelerate from rest to a speed of 25 m/s in a time of 8.00 s. What is the average power must the motor produce to cause this acceleration? Ignore friction losses. a. 62.8 hp b. 50.2 hp c. 52.8 hp d. 60.2 hp 13. Two forces vector A and B act on the same point. If A = 50N, 30 degrees and B = 40N, 120 degrees, what is the resultant force? a. 64 N b. 46 N c. 106 N d. 94 N 14. With the aid of a pulley, a mechanic raises a 40 kg engine to a height of 15 m in 3 minutes. Find the average horsepower required/ a. 1.0 HP b. 0.0438 HP c. 0.6 HP d. 0.5 HP 15. What average force is necessary to stop a bullet of mass 10 g and speed of 200 cm/sec as it penetrates wood 15 cm thick? a. 1512 N b. 1411 N c. 1333 N d. 1443 N 16. How much work is performed in steadily dragging a sled of 20 m horizontally when the force of 80 N is applied by a rope making an angle of 30 degrees with the horizontal ground? a. 693 N-m b. 639 J c. 1386 N-m d. 936 J 17. A block weighing 500 kN rests on a ramp inclined at 39 degrees with the horizontal. What is the force that tends to move the block down the ramp? a. 389 kN b. 315 kN c. 351 kN d. 242 kN 18. A ball was thrown upward with an initial velocity of 50 ft/s. how high does it go? a. 39 ft b. 30 ft c.20 ft d. 45 ft 19. If the absolute pressure at the bottom of the ocean is 120 kPa, how deep is the water at this point? a. 1.90 m b. 1.85 m c. 1.78 m d. 1.82 m 20. A DC-9 jet with a takeoff mass of 120 tons has two engines producing average force of 80,000 N during takeoff. Determine the plane's acceleration down the runway if the takeoff time is 10 seconds. a. 1.42 m/s2 b. 1.33 m/s2 c. 2.02 m/s2 d. 1.67 m/s2 140 21. What is the resultant of a displacement of 6 miles north and 9 miles east? a. 11 miles, N 56oE b. 11 miles, N 54oE c. 10 miles, N 56oE d. 10 miles, N 54oE 22. Determine the vertical pressure due to column of water 85 m high. a. 8.33 x 105 N/m2 b. 8.33 x 104 N/m2 c. 8.33 x 106 N/m2 d. 8.33 x 103 2 N/m 23. A 200 gram apple is thrown from the edge of a tall building with an initial speed of 20 m/s. What is the change in kinetic energy of the apple if it strikes the ground at 50 m/s? a. 130 joules b. 210 joules c. 100 joules d. 81 joules 24. Find the length of vector (2,4,4). a. 7.00 b. 8.75 c. 6.00 d. 5.18 25. The horsepower required to raise a 150 kg drum to a height of 20m over a period of one minute is: a. 0.41 hp b. 0.81 hp c. 0.66 hp d. 1.12 hp 26. According to the Chemiccal Engineering Law of 2004, who appoints the members of the ChE Regulatory Board? a. Professional Regulation Commission b. President of the Country c. President of PIChE d. Commission on Higher Education 27. The decree on Pollution Control issued in 1976 is a. PD 894 b. PD 984 c. PD 349 d. PD 232 28. Includes individual names and surnames, firm names, devices or words used by one to identify in his business, vocations or occupations. a. Trademark b. service mark c. trade name d. brand name 29. A chemical engineer who violates the provisions of the ChE law, upon conviction, shall be sentenced to a fine or imprisonment, upon the discretion of the court, of not more than a. 5 years b. 6 months c. 10 years d. 20 years 30. The Chemical Engineering Law was signed on __________. a. May 13, 2004 b. May 11, 2004 c. May 10, 2004 d. May 12, 2004 141 ANSWER KEY Physics, Statics, Dynamics, ChE Laws and Ethics 1. C. 121 m 2. C. 50.5 N 3. B. 31 m/s 4. A. 450 m/s 5. B. 21 m/s 6. B. 19.8 m/s 7. C. 46 s 8. A. 381 kg 9. C. 0.13 hp 10. C. 50.48 m 11. D. 40oC 12. A. 62.8 hp 13. A. 64 N 14. B. 0.0438 hp 15. C. 1333 N 16. C. 1386 N-m 17. B. 315 kN 18. A. 39 ft 19. A. 1.90 m 20. B. 1.33 m/s2 21. A. 11 miles 22. A. 8.33 x 105 N/m2 23. B. 210 joules 24. C. 6 25. C. 0.66 hp 26. B. President of the country 27. B. PD 984 28. C. Trade Name 29. A. 5 years 30. A. May 13, 2004 142 SOLUTIONS 1. Sy = 80 m Vo = 30 m/s Sx = ? Sy = Vot + ½ gt2 80 = vo sin θt + ½ gt2 80 = 0.30(0)t + ½ (9.81)t2 t = 4.039 s Sx = vo cosθt Sx = 30 cos (0) (4.039) Sx = 121.17 m 2. F = ma = 5.00 (0.3) F = 1.5 kg m/s2 W = mg = 5.00 (9.81) W = 49.05 kg m/s2 F = T-W 1.5 = T – 49.05 T = 50.55 N 3. Y = 49 meters y = vot + ½ gt2 49 = 0 + ½ gt2 t = 3.16 s v = vo + αt v = 0 + 9.81(3.16s) v = 30.9996 m/s = 31 m/s 4. m = 80 g v =? m1v1= m2v2 8g (v1) = (9000 g)(40 cm/s) v1 = 45000 cm/s = 450 m/s 143 5. S = rθ 1200 rev 1 hr 2 = (10 m)(hr)(3600 s)(1 rev) = 21 m/s 6. S = 20 m vo = 0 v=? v2 = vo2 +2as v = √0 + 2(9.81)(20) v = 19.81 m/s 60 mi 1.609 km 1 000 m 1 hr 7. v0 = hr (1 mi) (1 km) (3600 s) = 26.82 S = 2000 ft = 609.6 m v=0 m s v2 = vo2 + 2as 02 = (26.82 m/s)2 + 2a(609.6 m) a = -0.59 v = vo + at 0 = 26.82 + (-0.59)(t) t = 45.45 s = 46 s 8. 0.25 hp (W = Fd W F= d = 9. W t = Fd t 10. S = L + 746 W 1 hp) = 186.5 W 186.5 J/s m s 0.05 m (9.81 2) = mgd 8 d2 3L t − S = 50 N/m + = 144 54.2418 kg (9.81)(92.1595) 65 s 32d4 5 L3 8(3)2 3(50) 11. mcpΔT = mcp ΔT 60 - X = X - 20 X = 40 oC 12. m = 1200 kg vo = 0 = 380.224 kg − 32 (3)4 5(50)3 = . = 99.8332 W = . vf = 25 m/s t = 8.0 s P= 1 25m 2 (1200 kg)( ) 2 s 8s = 46875 W = . 13. ΣFx = 50 cos 30o – 40 cos60o ΣFx = -20 + 25√3 ΣFy = 50 cos 30o + 40 cos 60o ΣFy = 25 + 20√3 R = √ΣFx + ΣFy = 64.0312 N 14. m = 40 kg h = 15 m t = 3 min P= W t = mgh t = m s 60 s 3 min( ) 1 min (40 kg)(9.81 2)(15 m) 1 hp = 32.7 W 32.7 W (746 W) = . 15. m = 10 g = 0.010 kg v = 200 m/s ½ mv2 = Fd 1m ½ (0.010 kg)(200 m/s) = F (15 cm) (100 cm) F = 1333.33 N 16. d = 20 m F = 80 N W = Fd = F cos 30o d = 80 (cos 30) (20) W = 1385.6406 Nm 17. ΣFy = F – W cos 39 = 0 F = Wsin39 = 500 kN sin 39 F = 315 kN 18. Vo = 50 ft/s V=0 V2 = v02 - 2as 0 = 502 – 2 (32.2) s S = 38.82 ft = 39 ft 145 19. Pabs = Patm + Pgauge Pabs – P atm = Pgauge Pgauge = pgh (120,000 Pa – 101325 Pa) = 1000 kg/m3 (9.81m/s2) (h) h = 1.9037 m 21. R = √62 + 92 = 10.82 = 11 miles 22. Pgauge = pgh = (1000 kg/m3) (9.81 kgm/s2)(85m) Pgauge = 8.34 x 105 N/m3 1 23. m = 200 g vo = 20 m/s v = 50 m/s KE = ½ m(v2 – vo2) 1 kg = ½ (200 g) (1000 g)(502 -202) KE = 200 J 24. L = √22 + 42 + 42 = 25. m = 150 kg h= 20 m t = 1 min P= W t = PE t = mgh t 1 hp = 9.81m)(20 m) s2 60 s 1 min( ) 1 min (150 kg)(P = 490.5 W (746 W) = 0.67 hp 146 DIFFERENTIAL CALCULUS 1. Differentiate: y = sin (√x − 1) 2. Differentiate: y = x2cos2x Differentiate: y = √3 – 2x2 Differentiate: y = arctan3x Differentiate: y = (arcsin4x)2 Find the radius of the largest right circular cylinder inscribed on a sphere of radius 5. A rectangular box open at the top is to be formed from a rectangular piece of cardboard 3 inches by 8 inches. What size square should be cut from each corner to form the box with maximum volume? 8. A painting of height 3 feet hangs on the wall of a museum, with the bottom of the painting 6 feet above the floor. If the eyes of an observer are 5 feet above the floor, how far from the base of the wall should the observer stand to maximize his angle of vision? 9. Find the dimension of the rectangle of largest area whose base is on the x axis and whose upper two vertices lie on the parabola y = 12 - x2. What is the maximum area? 10. A cylinder is inscribed in a sphere with a radius of 10cm. what is the radius and height of the cylinder which yield a maximum volume? 3. 4. 5. 6. 7. INTEGRAL CALCULUS 5 1. Evaluate: ∫4 (2. Evaluate: 3. Evaluate: 4. Evaluate: 2 – x) dx √x /2 ∫0 (sin5 Θ)(cos 5 Θ)d Θ 1 ∫0 ∫0 (xsiny)dxdy 2 y ∫0 ∫0 (3x 2 + 9y 2)dxdy 5. Find the area bounded by the curves y2 = 4x and y + 2x = 12. 6. Find the area of the region above the x-axis bounded by the function y = 4x - x – 3. 7. Find the area bounded by the line x – 2y + 10 = 0, the coordinate axis in the first quadrant and line x = 10. 8. What is the area of the region bounded by the curve x2 + 2x = 8 – y and the x axis. 9. Find the area bounded by the parabolas y2 = 4x and x2 = 4y 10. Find the area bounded by the curves x2 + y2 = 9 and 4x2 + 9y2 = 36 on the first quadrant. 147 DIFFERENTIAL EQUATION 1. What is the solution of the DE (6x+y2)dx + y (2x-3y)dy=0 2. What is the general solution (x5 + 3y) dx – x dy = 0 3. Eliminate the arbitrary constant in the following equation: x 3 – 3x2y = c 4. Eliminate the arbitrary constant in the following equation: y = c 1e-2x + c2e3x 5. Obtain the differential equation of the family of straight lines with slope and y- intercept equal. 6. Write a differential equation for the family of circles with center on the x – axis. 7. Solve xy' (2y – 1) = y (1- x). 8. Obtain a general solution to the following differential equation: (1 + y2) dx + (1 + x2)dy =0 9. Obtain a particular solution for the following differential equation 2xyy' = 1 + y 2, given x = 2 and y = 3. 10. Solve for the general solution of the following differential equation: 3(3x 2 + y2)dx – 2xydy = 0 11. Determine the integrating factor for the following differential equation: y' – 3y = 6 12. Solve for y: (D3 – 3D2 + 3D – 1)y = 0. 13. Solve for y: (4D4 + 4D3 – 13D2 – 7D + 6)y = 0. 14. Solve (D2 + 3D – 10) y= 0, when x=0, y=0 and x=2, y=1. 15. Find the orthogonal trajectories of the family of curves y = cx2. 148 DIFFERENTIAL EQUATION 16. Determine the differential equation of the family of circles with center on the y – axis. dy 3 y sin 2 x, y 0 6 , then y 2 most nearly is dx dy 18. The form of the exact solution to 2 3 y e x , y 0 5 is dx 17. Given 2 19. The following nonlinear differential equation can be solved exactly by separation of variables. d 10 6 2 81, 0 1000. The value of 100 most nearly is dt 20. It has been identified that in chemical reaction, the time rate change (conversion) of the unconverted substance is proportional to the amount of the unconverted substance. If half of the substance has been converted after 10 s, find when the 9/10 of the substance will have been converted? 21. The radioactive isotope of Pb-209 decays at a rate proportional to the amount present at that time and has a half -life of 3.3 hours, if 1 gram of Pb is present initially, how long will it take for 90% of the lead to decay? 22. A tank initially holds 100 gallons salt solution in which 50 lbs of salt has been dissolved. A pipe fills the tank with brine at the rate of 3 gpm, containing 2 lbs of dissolved salt per gallon. Assuming that the mixture is kept uniform by stirring, a drain pipe draws out of the tank of a mixture at 2 gpm. Find the amount of salt in the tank at the end of 30 minutes. 149 ANSWER KEY Differential Calculus 1.y′ = cos(√x−1) 3.y′ = − 2. y′=−2x [x sin(2x) − cos(2x)] 2√x 2x 3 4. y′ = 9x2+1 √3−2x2 8 (sin−1 4x) 5. y′ = √1−16x2 7. 0.67 in 9. 32 units 6. 4.08 units 8. 2 units 10. x = 8.165 cm ; h= 11.55 cm Integral Calculus 6. 1.33 sq.units 7. 75 sq.units 8. 36 sq.units 9. 5.33 sq.units 10. 2.36 units 1. -3.56 2. 1/60 3. 1 4. 40 5. 41.67 sq.units Differential Equation 1. 3x + xy – y = C 2. dy/dx + (-3/x)y = x4 3. xdx-2ydx-xdy=0 4. y''-y'-6y =0 5. ydx - (x+1)dy =0 6. 1 + yy" +(y')2 =0 7. ln(xy)=x+2y+C 8. Arc tan(x) + Arc tan(y) + C=0 9. y = √5x − 1 10. 9x2 - y2 = Cx 11. e−3x 12. y = (C1 + C2x + C3x2)ex 2 2 3 3 1 13. y = C1 e−x + C2 e−2x + C3 e(2)x + C4e(2)x 1 14. y = e4 −e10 (e 2x − e −5x) dy 15. dx = −x 2y 16. xy"-(y')3 – y' = 0 17. 0.32 x 3x 18. y = (e2 + 4)e− 2 19. 8.1 + Ce −10 20. 33.23 s 21. 10.96 hours 22. 171.24 lbs. 150 −6t SOLUTIONS Differential Calculus 1. y = sin(√x − 1) Solution: dy d = [sin(√x − 1)] dx dx y′ = cos(√x − 1) d (√x − 1) dx y′ = cos(√x − 1)(′ = 1 2√x) (√ −) √ 2. y = x 2 cos2x Solution: dy d = [x2 cos(2x)] dx dx y= d 2 d [x · cos(2x) + x 2 · cos(2x)] dx dx d y′= 2x cos(2x) + (−sin(2x))· dx (2x)· x2 y′= 2xcos(2x) – 2 · d dx (x) · x2sin(2x) y′= 2xcos(2x)− 2·1x2sin(2x) y′= 2xcos(2x)−2x2sin(2x) Simplifying: y′=−2x [x sin(2x) − cos(2x)] 3. y = √3 − 2x 2 Solution: y= 1 d [(3 − 2x 2)2] dx 151 y′ = 1 2 (3 − 2x2) 1 y′ = 2 (3 − 2x2) ′ = − 1 −2 . d dx (3 − 2x2) 1 −2 (-4x) √ − 4. y = arc tan3x y= d [arc tan(3x)] dx dy 1 d = . (3x) 2 dx (3x) + 1 dx d (x) dx y′ = 9x 2 + 1 3. y′ = ′ = (3) (1) 9x 2 + 1 + 5. y = (arcsin4x)2 [y = arc sin(4x)2] d dx dy d = [arc sin(4x)]2 dx dx y ′ = 2 (arcsin 4x) d (arc sin4x) dx y ′ = 2 (arcsin 4x) . ′ = 1 √1 − (4x)2 . d (4x) dx (−) √ − 6. Given: R = 5cm let R = radius of sphere r = radius of cylinder h = height of cylinder Solution: 152 Volume of cylinder: V = πr²h V r² = h → equation 1 By the Pythagorean Theorem h R² = r² + (2)² = r² + r² = R² - h² 4 h² 4 r = √(R 2 − h2) 4 → equation 2 Set the equations (1) and (2) for r² equal. V πh = R² - h² 4 V = πR²h - h³ 4 Take the derivative with respect to h and set it equal to zero to find the critical point(s). dV/dh = R² − 3h²/4 = 0 R² = 3h²/4 4R²/3 = h² h = 2R/√3 Solve for r ; r = √(R² − h² 4) 2R r = √(R² − ((4) 3)² √ 2 r =√3 R² When R= 5 2 r = √3 (52) r = 4.08 units 7) V = L × W × H V = (8 − 2x)(3 − 2x)(x) V = 24x − 22x2 + 4x 3 V ′ = 24 − 44x + 12x2 0 = 4 (6 − 11x + 3x2) 153 0 = 4(3x − 2)(x − 3) 2 x=3;x=3 if x= ; V= 7.4074 in3 x= 3 ; V = -13 Therefore to form a box with maximum volume, 2/3 in (0.67 in) should be cut from each corner. 8. = − d = d − d 4 tan = x ; xtan = 1 x sec2 d + tandx = 0 dx = −xsec2 βdβ tanβ Solve for x: x= −tanβdx sec2 βdβ x= −tanβ(−xsec2αdα) sec2 βdβtanα sec2 βtanα = tanβsec2 α (1 + tan2 β) tanα = tanβ(1 + tan2 α) [1 + (4/x)2](1/x) = (4/x) [1+(1/x)2] X2 + 16 = 4x2 + 4 X2 − 4x2 +12 = 0 (x+6) (x-2) = 0 x= 2 units 9. y = 12 – x2 x2 = 12 – y (x-h)2 = -4a (y-k) (x-0)2 = -1 (y -12) 154 1 tan = x ; xtan = 1 x sec2 αdα + tan αdx = 0 dx = −xsec 2 αdα tanα V (0,12) A rectangle = L x W L= 2x = 2(2) =4 A = x (12-x2) W = y = 12-x2 A= 12x – x3 W=y =12 – 22 = 8 dA =0= 12 – 3x2 12 = 3x2 Area rectangle = LW X2= 4 A = 4 (8) x = ±2 A = 32 units 10. Given: r = 10cm let x = radius of cylinder h = height of cylinder r = radius of sphere Volume of cylinder: V = πx²h → equation 1 dV dx = π (x2 dh dx + 2xh) →equation 2 By the Pythagorean Theorem h h² 2 4 r² = x² + ( )² = x² + r² = x² 2x + h² 4 h dh 2 dx =0 →equation 3 → equation 4 Using eqtn (3) and (4) dV dx = π(2rh − 3h3/4) 0 = π(2rh − 4h3) 2rh = 3h3 4 3 h = √ (10cm) = 20√3 3 cm or 11.55 cm Substituting the value of h to equation 3 and r=10cm 10² = x² + h² 4 = x² + (√2x) ² 4 x = 8.165 cm 155 SOLUTIONS Integral Calculus 5 1. ∫4 (2 √x 1 5 − x) dx = ∫4 (2x −2 − x)dx 1 2(x)2 = ∫ (√ 1 2 − x2 5 | 2 4 −) = −. 2. ∫02 cos5 sin5 d Use cos 2 (x) = 1 − sin2 (x) ∫ cos 5 sin5 d = ∫ cosx • sin5 x (sin2 x − 1)2 dx Let u = sinx ; du dx = cosx ∫02 sin5 cos 5 d = ∫ u5 (u2 -1)2du = ∫(u9 − 2 u7 + u5) du = = = u10 10 − u8 4 sin10 (x) 10 − + ; u = sin x +C sin6 (x)(6 sin4 (x)−15sin2 x+10) +C 60 sin6 (2)(6 sin4 (2)−15sin2 (2)+10−0 60 ∫ = 1 6 sin8 x sin6 x + 4 6 = u6 1 1 3. ∫0 ∫0 xsinydxdy = ∫0 − cos y |0 xdx = ∫0 (− cos − cos(0) xdx 1 1 = ∫0 (1 + 1)xdx = ∫0 2xdx 2 y ∫ ∫ = 2 3x 3 4.∫0 ∫0 3x 2 + 9y 2 dxdy = ∫0 156 3 + 9y 2 |y0 dy 2 = ∫0 (y 3 + 9y 3)dy 2 = ∫0 10y 3 dy 2 = ∫0 10y 4 |20 ∫ ∫ + = 9 5. A1 = ∫4 [(12 − 2x) + 2√x)]dx A1 = 61 sq. units 3 4 A2 = 2 ∫ 2√x dx 0 3 4(x)2 4 | A2 = 3/2 0 A2 = 64/3 sq. units Atotal = A1 +A2 = 61/3 + 64/3 Atotal =41.67 sq. units 6. y= 4x-x2-3 (x-3)(x-1)=0 3 A= ∫1 (4x − x 2 − 3)dx A= 4x 2 2 − x3 3 − 3x|31 A= = . 7. dA= (y1-y2)dx 10 A= ∫0 ydx 10 x A =∫0 (5 +) dx 2 157 x2 A= 5x +2(2) |10 = 5(10) + 0 (10)2 4 A = 75 sq. units 8. x2+2x=8-y y= -x2-2x+8 (x-2) (x+4) =0 dA= y1-y2 dx 2 A=∫−4(−x 2 − 2x + 8) dx A= −x 3 3 2 − x 2 + 8x|−4 A= 36 sq units 9. y2=4x and x2=4y point of intersection (0,0) and (4,4) 4 A=∫0 (2√x − 3 = 2(x)2 A= 158 3 2 − x2 4) dx x3 |4 4(3) 0 or 5.33 sq. units − 0 SOLUTIONS Differential Equation ∑ ∫ DI + NDI = C DI = 6xdx, -3y2dy NDI = y2dx, 2xydy ∫(6xdx – 3 y2dy) + ∫y2∂x = C 6 (x2/2) – 3(y3/3) + xy2 = C 3x2 + xy2 – y3 = C 2. v (x) = e∫P(x)dx y-v(x) = ∫v(x).Q(x)dx + C (since v≠0) y = v-1(x)∫v(x).Q(x)dx + cv-1(x) dydx + P(x)y = Q (x) (x5+ 3y) dx – x dy = 0 -x(dy) = -(x5+3y)dx dy/dx + (-3/x)y = x4 3. [x 3 − 3x 3 y = C] d dx 3x 2 − 3x 2 dy − 3y(2x)dx = 0 3x 2 −6xydx−3x 2 dy=0 3x − − = 159 4. y = c1e-2x + c2e3 ← (1) y' = -2C1 e-2x + 3 C2e3x ← (2) y' + 2y = 5C2e3x y'' + 2y'=5C2e3x (3) ← (3) ← (4) y'' + 2y'= (y'+2y) (3) y'' + y' - 6y = 0 5. y = mx + b ; m = b y = mx + m [y = m(x + 1)] d dx d Slope = y-int. dx = m y= y= dy dx dy dx (x) + dy dx (x + 1) ydx = xdy + dy − (+) = 160 y m=b x 6. x2 + y2 + Ax + By + C =0 x2 + y2 + Ax + C =0 2xdx + 2ydy + Adx = 0 y2 = C – Ax – x2 2yy' = -A – 2x Y' = (-A – 2x)/ 2y 2yy''/2 + y'(2y)/2 = -1 yy'' + (y')2 = -1 (y')2 + yy" + 1 = 0 7. xy' (2y-1) = y(1-x) dx y(2y – 1) = y(1 − x) dx x(2y-1) dy = y(1-x) dx 2y−1 y dy − 2 ∫ dy − ∫ 1−x dy y x dx=0 −∫ dx x + ∫ dx = C 2y-lny-lnx+x=C 2y+x+C=lnx+lny ln(xy)=2y+x+C 8. (1 + y2) dx + (1 + x2)dy = 0 ∫(1/(1+x2))dx = ∫(1/(1+y2))dy Arc tan(x) + Arc tan(y) + C =0 161 9. 2xy(dy/dx) = 1 + y2 dx x = 2y(dy) 1+ y 2 Integrating both side: ln x = ln (1+y2) + ln C Taking exponentials:x = C(1+y2) when x = 2 and y = 3 2 = C (1+ 32) C = 1/5 Thus y particular solution is = √ − 162 10. We cannot separate the variables, but M(x, y) and N(x, y) are homogeneous functions of degree 2. Substituting: y = vx and dy = v dx + x dv we get (9 + v2)dx – 2v(v dx + x dv) = 0 Separating variables 9(dx) + v2(dx) – 2v2(dx) + 2vx(dv) = 0 9(dx) - v2(dx) + 2xv(dv) = 0 (9- v2)(dx) + 2xv(dv) = 0 – dx x = 2v(dv) 9−v 2 Integrating ln (9-v2) = - ln x + ln C Taking exponentials x(9-v2) = C since v = y/x 9x2 - y2 = Cx 11. y ′ − 3y = 6 dy dx − 3y = 6 P (x) = −3 Q(x) = 6 Integrating Factor: e ∫ P(x)dx = e ∫ P(−3)dx ∫ () = − 12. (D3 – 3D2 + 3D – 1)y = 0. x3 – 3x2 + 3x – 1 = 0 (x-1)(x-1) (x-1) = 0 x = 1 ;occuring 3 times y = (C1 + C2x + C3x2)ex 13. (4D4 + 4D3 – 13D2 – 7D + 6)y = 0. 4m4 + 4m3 – 13m2 – 7m + 6 = 0 (m+1)(4m3-13m+6) = 0 (m+1)(m+2)(4m2-8m+3) = 0 (m+1)(m+2)(2m-1)(2m-3) = 0 Roots: m = -1, -2, ½, 3/2 General Equation: = − + −+ (/)+ (/) 14. D2 + 3D – 10 = 0 (D + 5) (D – 2) = 0 D = -5 ; D =2 y = C1e-5x + C2e2x 163 when y=0 ; x=0 0= C1e-5(0) + C2e2(0) 0= C1+ C2 When x=2 ; y=1 1= C1e-5(2) + C2e2(2) 1 −1 C2= e4 −e10 ; C1= e4 −e10 y= − (− −) 15. y = Cx 2 y =C x2 x 2 dy−y(2x)dx (x 2)2 x 2 dy−(2xy)dx (x)4 =0 =0 x 2 dy − (2xy)dx = 0 dy dx dy dx = 2xy 2x 2 2y = 2x Orthogonal trajectories: = 164 − 16. x2 + (y-k)2 = r2 Differentiate: 2x+2(y-k)y' = 0 x+yy' – ky' = 0 k = x/y + y 0= y ′ (1)−xy" (y′)2 + y′ y'-xy"+(y'3 = 0 xy"-(y')3 – y' = 0 17. Using homogenous Solution, (2D+3)y = 0 2r + 3 = 0 r = -1.5, Yn = Ce-1.5x,Yp = A sin2x + B cos2x y ′ → 2y′ (Asin2x + Bcos2x) + 3(Asin2x + Bcos2x) = sin2x 2(2Acos2x − Bsin2x) + 3(Asin2x + Bcos2x) = sin2x (4A + 3B)cos2x + (−4B + 3A)sin2x = sin2x Equating sin2x and cos2x on both sides, -4B+3A=1 3B+4A=0 A = 0.12 B = -0.16 Yp = 0.12 sin2x – 0.16cos2x Y = Yn + Yp = Ce-1.5x + 0.12 sin2x – 0.16 cos2x y (0) = 6 y = Ce-1.5(0) + 0.12sin2 (0) – 0.16 cos2 (0) 6 = C – 0.16 C = 1.16 y(2) = 6.16e-1.5(2) + 0.12sin2 (2) – 0.16 cos2 (2) y(2) = 0.32 19. d dt d dt 2 = −10−6 (- 81) 2 + 10−6 = 165 I. F. = e ∫ 10 −6 dt −6 t = ∫ 8.1 × 10−5(e10 e 10 −6 t = 8.1 × 10−5e10 t (106) −6 t dx dt −6 − = -kX At t=0 ; x= xo; C=xo x = Ce-kt 1 xo = xo(e−kt) 2 k= 0.693 at x= 9/10 ; t=? 1 xo = xo(e−0.693t) 10 t=33.23 s N(t) = Ce-kt t = 0, n (t) = 1 1 = e-k (0) C=1 At t = 3.3, n (t) = 0.5 n (t) = Ce-kt 0.5 = e-k (3.3) ln 0.5 = - 3.3 k 21. k= ln0.5 −3.3 k = 0.21 90% decayed, n(t) = 0.1, t = ? n (t) = Ce-kt 0.1 = e-0.21t ln 0.1 = - 0.21t t= ln0.21 −0.2 = . 166 −6 t e 10 = . + − 20. = e 10)dt 22. . Let Q= amount of salt in the mixture 100 + (3-2)t = 100+ t = Volume of mixture at any time t Q 100+t = Concentration of salt dQ = rate gain − rate loss dt dQ Q = 3(2) − 2( ) dt 100 + t dQ 2)=6 + Q(dt 100 + t 2 i. f. = e∫ P(t)dt ;where P(t)=100+t ; A(t)= 6 2 i. f. = e∫ P(t)dt = e∫100+t = e2ln(100+t) = (100 + t)2 Substitute: Q(100+t)2=∫ 6(100 + t)2 dt + C = 2(100 + t)3 +C When t=0 ; Q=50 50(100)2=2(100+t)3 +C C= -1.5x106 When t= 30 min ; Q= ? Q(100+30)2=2(100+30)3 -1.5x106 Q = 171.24 lbs. 167 ENGINEERING ECONOMY 1. What is the effective rate corresponding to 18% compounded daily? Take 1 year is equal to 360 days. 2. What nominal rate compounded semi-annually, yields the same amount as 16% compounded quarterly? 3. The amount of P50,000 was deposited in the bank earning an interest of 7.5% per annum. Determine the total amount at the end of 5 years, if the principal and interest were not withdrawn during the period. 4. The sum of P20,000 is left to Robert as a will, however, with a condition that the sum will be held in a trust fund until it amounts to P50,000. When will Robert receive the money if the fund is invested at 8% compounded quarterly? 5. A sum of P1,000 is invested now and left for 8 years, at which time the principal is withdrawn. The interest has accrued is left for another 8 years. If the effective annual interest is 5%, what will be the withdrawal amount at the end of 16th year? 6. Today, a businessman borrowed money to be paid in 10 equal payments for 10 quarters. If the interest rate is 10% compounded quarterly and the quarterly payment is P2,000, how much did he borrow? 7. Mr. Ayala borrows P100,000 at 10% effective annual interest. He must pay back the loan over 30 years with uniform monthly payments due on the first day of each month. What does Mr. Ayala pay each month? 8. A person buys a piece of lot for P100,000 down payment and 10 deferred semiannual payments of P8,000 each, starting 3 years from now. What is the present value of the investment if the rate of interest is 12% compounded semi-annually? 9. At 6%, find the capitalized cost of a bridge whose cost is P250M and life is 20 years, if the bridge must be partially rebuilt at a cost of P100M at the end of each 20 years. 10. A man wants to make 14% nominal interest compounded semi-annually on a bond investment. How much should he be willing to pay now for a 12%, P10,000-bond that will mature in 10 year; and pays interest semi-annually? 168 11. What is the maximum amount an investor should pay for a 25-year bond with a P20,000 face value and 8% coupon rate (interest only paid semi-annuaily)? The bond will be kept to maturity. The investor's effective annual interest rate for economic decisions is 10%. 12. A manufacturer produces certain items at a labor cost per unit of P315, material cost per unit of P100 and a variable cost per unit of P3. If the item has a selling price of P995, how many units must be manufactured each month for the manufacturer to break even if the monthly overhead is P461,600. 13. ABC Corporation manufactures bookcases that it sells for P65 each. It costs ABC P35000/yr to operate it: plant. This sum includes rent, depreciation charges on equipment, and salary payments. If the cost to produce one bookcase is P50, how many bookcases must be sold each year for AbC to avoid taking a loss? 14. The volatility of a stock is found to be 1.5times the stock market average. If the risk premium for buying stocks averages 8.3% and the present treasury bill rate (assumed to be risk free) is 7%, what is most nearly the expected return (ER) on the stock? 15. A manufacturer of sports equipment produces tennis rackets for w/c there is a demand of 200/month. The production setup cost for each batch of rackets is P300. In addition, the inventory carrying cost for each racket is P24/year. Using the EOQ model, w/c is most nearly the best production batch size for the rackets? 16. . A student needs P4000/year for 4 years to attend college. Her father invested P5000 in a 7% account for her education when she was born. If the student withdraws P4000 at the end of her 17th, 18th, 19th and 20th years, how much money will be left in the account at the end of her 21st year? 169 ANSWER KEY Engineering Economy 1. Ans. 2. Ans. 3. Ans. 4. Ans. 5. Ans. 6. Ans. 7. Ans. 8. Ans. 9. Ans. 10. Ans. 11. Ans. 12. Ans. 13. Ans. 14. Ans. 15. Ans. 16. Ans. 170 19.72 % 16.32% P71781.47 11.5678 years P705.42 P17504.12786 P839.1989 P143999.08162 P 295.3076 M 600 P16,723.57 800 units 2334/yr 19.45% 245 units P1700.01 SOLUTIONS 0.18 1. ER = (1+ 360)3 6 0 -1 = 0.1972 x 100 ER = 19.72 % Ans. 19.72 % 0.16 i 2. (1+ 4)4 = (1+ 2)2 = 0.1632x100 i = 16.32% Ans. 16.32% 3. F = P(1+i) n F = P 50000 (1+0.075) 5 F = P71781.47 Ans. P71781.47 4. 50000 = 20000(1 + N= 11.5678 years 0.08 4 n) 4 Ans. 11.5678 years 5. F F F F F = 1000(1+0.05) 8 = P1477.4554 – P1000 = P477.4554 = 477.4554(1+0.05) 8 = P705.42 Ans. P705.42 6. P = 2000 0.1 [1- (1+ 0.1 -1 0)] 4 P = P17504.12786 Ans. P17504.12786 i 7. 1+0.10 = (1+ 12)1 2 i = 0.0956 or 9.57% (monthly) Annuity: A 0.0956 100000 = 0.0956 [1-(1+ 12) -(30(12)-1)]+A 12 A = P839.1989 Ans. P839.1989 171 8. x y 8000 (1+(0.12/2) -1 1 2 6000 (1+(0.12/2) -2 ∑xý, 1,10 P = 58880.69641 PF = 58880.69641 (1+(0.12/2)) -5 P 1 = 43999.08162 + 100000 P 1 = P143999.08162 Ans. P143999.08162 9. C a p C = PC+[(FC-SV)/(1+i) n -1]+(AC/i) 100 = 250 + 1.0620 −1 + 0 CapC = P 295.3076 M Ans. P 295.3076 M 10. P = Fr i (1+(1+i) -n) -x ∑20 x=1 1.07 = 10.5940; r=0.07 I = (0.12/2)(10000) = 600 Ans. 600 x 11. 0.10 = (1+ 2) 2 -1 x = 0.097618 or 9.7618% I = 20000(0.08/2) = 800 0.097618 -x ∑50) = 18.597076 x=1(1 + 2 P = 800 (18.597076) + 20000 (1+ P = P16,723.57 0.097618 -5 0) 2 Ans. P16,723.57 12. 995x = 315x + 100x + 3x + 461600 x = 800 units Ans. 800 units 13. 65x = 35000 + 50x x = 2333.3333 bookcases/yr x = 2334/yr bookcases to avoid taking a loss Ans. 2334/yr 172 14. V = 1.5 (SMA) Risk = 8.3% T. bill rate = 7% ER = (V)(SMA) + T = 1.5 (8.3) + 7 ER = 19.45% Ans. 19.45% 15. Demand = 200/month Purchase cost = P300/batch Inventory cost = P24/yr 2(200)(300) EOQ = √ 24/12 EOQ = 244.95 units or 245 units Ans. 245 units 16. F = F 1 – F 2 F 1 = 5000 (1.07) 2 1 = 20702.81187 ∑4x=1(1.07)x = 4.7507 F 2 = 4.7507(4000) = 19002.8 F = 20702.81187 - 19002.8 F = P1700.01 Ans. P1700.01 173 STRENGTH OF MATERIALS A rod 200cm long and of diameter 3.0cm is subjected to an axial pull of 30kN. If the Young's modulus of the material of the rod is 200GPa. 1. Determine the stress. 2. Determine the strain. 3. Determine the elongation of the rod. 4. A member formed by connecting a steel bar to an aluminium bar is shown below. Assuming that the bars are prevented from buckling sideways, calculate the magnitude of P, that will cause the total length of the member to decrease 0.30mm. The values of elastic modulus for steel and aluminium are 200GPa and 65GPa respectively. For problems 5-6 The bar shown in the figure is subjected to a tensile load of 150kN. If the stress in the middle portion is limited to 160MPa. Young's modulus given as 200GPa. 5. Determine the diameter of the middle portion. 6. Find the length of the middle portion if the total elongation of the bar is to be 0.25mm. 7. A brass bar, having a cross-sectional area of 1000 mm 2, is subjected to axial forces as shown below. Find the elongation of the bar. Take E= 105GPa. 174 For problems 8 to 13 Three bars made of copper, zinc and aluminium are of equal length and have crosssection 500, 750 and 1000 mm2 respectively. They are rigidly connected at their ends. If this compound member is subjected to a longitudinal pull of 250kN. Take the value of E for copper = 130GPa, zinc = 100GPa and aluminium = 80GPa. 8. Determine the stress through the aluminium bar. 9. Determine the stress through the zinc bar. 10. Determine the stress through the copper bar. 11. Determine the proportional load experienced through the copper bar. 12. Determine the proportional load experienced through the zinc bar. 13. Determine the proportional load experienced through the aluminium bar. For problems 14 to 17 A steel rod 5cm diameter and 6m long is connected to two grips and the rod is maintained at a temperature of 100degC. 14. Determine the stress exerted when the temperature falls to 20degC if the ends do not yield. 15. Determine the pull exerted when the temperature falls to 20degC if the ends do not yield. 16. Determine the stress exerted when the temperature falls to 20degC if the ends yield by 0.15cm. 17. Determine the pull exerted when the temperature falls to 20degC if the ends yield by 0.15cm. For problems 18 to 19 A metallic bar of length 30cm, breadth 4cm and depth 4cm when the bar is subjected to an axial compressive load of 400kN. The decrease in length is given as 0.075cm and increase in breadth is 0.003cm. 175 18. Determine the value of Young's modulus. 19. Determine the value of Poisson's ratio. 20. A steel bar 300mm long, 50mm wide and 40mm thick is subjected to a pull of 300kN in direction of its length. E = 200GPa and Poisson's ratio = 0.25. 21. A metallic bar 300mm x 100mm x 40mm is subjected to a force of 5kN(tensile), 6kN(tensile) and 4kN(tensile) along x,y and z directions respectively. Determine the change in the volume of the block. Take E = 200GPa and Poisson's ratio = 0.25. For problems 22 to 23 A metallic bar 250mm x 100mm x 50mm is loaded as shown in the figure below. Take E = 200GPa and u = 0.25. 22. Find the change in volume. 23. Find the change that should be made in the 4MN load in order that there should be no change in the volume of the bar. For problems 24 to 26 A bar of 30mm diameter is subjected to a pull of 60kN. The measured extension on gauge length of 200mm is 0.1mm and change in diameter is 0.004mm. 24. Calculate the Young's modulus. 25. Calculate the Poisson's ratio. 26. Calculate the Bulk's modulus. 176 ANSWER KEY Strength of Materials 1. Ans. 42.44 MPa 2. Ans. 0.000212205 3. Ans. 0.00042 m 4. Ans. 405.7803 kN 5. Ans. 0.03 m 6. Ans. .375 cm 7. Ans. -1.14x10 -4 8. Ans. 147.72 MPa 9. Ans. 113.64 MPa 10. Ans. 90.90 MPa 11. Ans. 73 863.64 N 12. Ans. 85.2272 kN 13. Ans. 90909.09 N 14. Ans. 192 MPa 15. Ans. 376,991.12 N 16. Ans. 242 MPa 17. Ans. 475165.89 N 18. Ans. 100 GPa 19. Ans. 0.3 20. Ans. 225 mm3 21. Ans. 5.65mm3 22. Ans. 250 mm3 23. Ans. 2MN must be applied 24. Ans. 169.7653 GPa 25. Ans. 0.27 26. Ans. 123. 0183 GPa 177 SOLUTIONS (0.03 m)2 1. A = 4 = 7.068583x10 -4 m 2 axial pull Stress = area 30000 = 7.068583x10−4 Stress = 42,411,320.98 Pa or 42.44 MPa Ans. 42.44 MPa 2. Strain = /E 42.441x106 = 200x109 Strain = 0.000212205 Ans. 0.000212205 PL 3. Elongation of the rod = = AE 30000(2m) 7.068583x10−4 (200x109) Elongation of the rod = 0.00042 m Ans. 0.00042 m 4. x = 0.30 mm Est = 200GPa E L = 65 GPa δT = 0.30 1000 PLst AstEst =P[+ PLL alEl 20/100 36/1002 (200x109) + 30/100] 100/1002 (65x109) P L = 405.7803 kN Ans. 405.7803 kN 5. 160x10 6 Pa = 150x10 3 /A A = 9.375x10 -4 9.375x10 -4 = (D)2 4 D = 0.03 m Ans. 0.03 m 6. δ = 0.25 1000 178 PL AE = = L/E 160x106 (L) (200x109) x = 45 – (31.25/2) = .375 cm Ans. .375 cm 7. E 1 = (50x103)(0.6 m) 1m 1000 mm (1000 mm)2(105x9) E 1 = -2.8571x10 -4 m decrease (-) E2 = (30x103)(1 m) 1m 1000 mm (1000 mm)2(105x9) E 2 = 2.8571x10 -4 m increase (+) E3 = (10x103)(1.2 m) 1m 1000 mm (1000 mm)2(105x9) E 3 = -1.1429x10 -4 m decrease (-) E T = -2.8571x10 -4 m + 2.8571x10 -4 m -1.1429x10 -4 m E T = -1.14x10 -4 Ans. -1.14x10 -4 8. 250 kN = FCu + 15/13 FCu + 16/13 FCu FCu = 73.8636 kN Cu = 73.8636 kN/500 Cu = 147.72 MPa Ans. 147.72 MPa Area mm 2 500 750 1000 Bars Copper Zinc Aluminum 9. Area m 2 5x10 -4 7.5x10 -4 1x10 -3 E (Pa) 130x10 9 100x10 9 80x10 9 P = 250 kN Total Load (P) = Load C + Load Z+Load A 250x103 N = (A 130x109 80x109 -4 A)(5x10) + (100x109 80x109 A)(7.5x10 -4)+(-3 A)(1x10) = 90909090.91Pa 2= 100x109 80x109 (90909090.91 Pa) 179 2= 113636363.6 Pa or 113.64 MPa Ans. 113.64 MPa 10. = F A = 16 (73.8636)(1000) 13 1000 10002 = 90.90 MPa Ans. 90.90 MPa 11. Pc = cAc 100x109 80x109 (90909090.91) (5x10- 4) Pc = 73 863.64 N Ans. 73 863.64 N 12. FL2n = 15 13 (73.8636) FL2n = 85.2272 kN Ans. 85.2272 kN 13. PA = AAA = 90909090.91 Pa (1x10-3) PA = 90909.09 N Ans. 90909.09 N 14. L = 6 (12x10-6/Co)(100-20) L = 5.76x10-3 m = δT 5.76x10-3 m = (6)/200x109) = 192 MPa Ans. 192 MPa 15. δ = 6m (12x10-6 m/Co)(100-20)Co = 5.76x10-3 = 5.76x10−3 m (200x109) 6m = 192 MPa P= A P = 192x106 Pa 4 (0.05)2 P = 376,991.12 N Ans. 376,991.12 N 16. δ thermal = (-) 5.76 m due to cooling 0.15 cm 100cm/m + 5.76x10-3 m = (6)/200x109) = 242 MPa Ans. 242 MPa 180 17. δ = 5.76x10-3 m + (1.5x10-3m) = 7.26x10-3 m = 7.26x10−3 m (200x109) 6m = 242 MPa PL = A PL = 242x106 Pa (0.05)2 4 P = 475165.89 N Ans. 475165.89 N 18. E = [0.075/100(4)(4)]/100 -1 =( ) 30 400x103 (100) E = 100 GPa Ans. 100 GPa 19. Longitude Strain = μ = b/ L = 0.075 cm 30 cm = 2.5x10 -3 L 7.5x10−4 2.5x10−3 μ = 0.3 Ans. 0.3 300x103 (40x50)/10002 200x109 [1.2 (0.25)] 20. Ev = Ev = 3.75x10-4 V = 3.75x10-4 (300)(50)(40) = 225 mm3 Ans. 225 mm3 21. V = xyz (1-2 μ) (1/E) (x + y+ z) = (300 x 100 x 40) (1-2(0.25))(1/200x109 Pa)(4 5 + 40(300) 300(100) 6 +40(100)) V = 5.65mm3 Ans. 5.65mm3 22. EL = −4x10 =[400x10 2x10 + ()()/ + ()()/]( ) ()()/ = 4x10-4 EV = 4x10-4 (1-2(0.25)) = 2x10-4 V = 2x10-4 (250)(100)(50) V = 250 mm3 Ans. 250 mm3 181 23. = 0 so that V = 0 ; 0= P =A 400x103 N x 2x106 N + + 0.05 m (0.25 m) 0.1m (0.25 m) 0.1 m (0.05 m) X = F = 6000 kN compressive Additional: 6000 kN – 4000 kN = 2000 kN so Additional 2MN must be applied; compressive load Ans. 2MN must be applied 24. E = PL/AΔ E= 60x103 (200)/1000 (30/100)2 0.1 4 (1000) E = 169.7653 GPa Ans. 169.7653 GPa 25. μ = Lateral Strain = Longitudinal Strain 0.004/30 0.1/200 = 0.27 Ans. 0.27 26. = [3(1-2μ)]-1 (E) = [3(1-2(0.27)]-1 (169.7653) = 123. 0183 GPa Ans. 123. 0183 GPa 182 PRELIMINARY EXAMINATION PHYSICAL AND CHEMICAL PRINCIPLES 1. From the standpoint of kinetic theory, a liquid may be considered as a continuation of the gas into the region of ________ volume and ________ molecular attraction. a. Rigid, stronger b. small, stronger c. large, smaller d. dynamic, smaller 2. In a small biochemical plant, a 450-L capacity steady state chemostat is being used to control the growth of microorganisms by adjusting the dilution rate. The Monod constant and the maximum specific growth rate are 0.83 mol/L and 0.85/h respectively. Given a limiting exit concentration of 0.74 mol/L, calculate the daily amount of the substrate that the bioreactor is able to process. a. 4327 L/d b. 5327 L/d c. 6327 L/d d. 7327 L/d 3. Deducing the structures of vitamins is important in understanding their biochemical function. Which woman was responsible for solving the structure of vitamin B12, the most chemically complex vitamin? a. Marie curie c. Mary Somerville b. Dorothy Hodgkin d.Barbara McClintock 4. Which interesting sounding scientist came up with the name "vitamin"? a. Emil Fischer c. J.B.S. Haldane b. Kazimierz Funk d. Friedrich Miescher 5. Supposed the following four salts all have the same numerical value of Ksp which is much less than one, which will have the highest solubility? a. AB b. AB2 c. AB3 d. A2B3 For numbers 6-8, choose on the following choices, a. b. c. d. First statement is true; Second statement is false First statement is false; Second statement is true Both statement is true Both statement is false 6. Enzyme is a protein which consists of amino acid residues. The total enzyme concentration stays constant during the reaction. 7. The length of the lag period depends on many factors such as age of microorganism and culture condition. The specific growth rate if the same for each microorganism and can be affected by several factors. 8. Industrial applications of biochemical processes are to use living cells or cellular components to effect the desired physical or chemical changes. Biological processes are prone to contamination. 183 9. An aqueous solution of molasses contains 20% by weight sucrose. The CO2 formed in the reaction can be considered as having a negligible solubility in the solution. Determine the % wt ethanol in solution after 98% of the sucrose has been converted to

ethyl alcohol by fermentation. a. 11.22% b. 22.33% c. 33.44% d. 44.55% 10. A 50.00 ml aliquot of 0.1000 M calcium nitrate is added to a 1.000 g sample containing sodium fluoride. After the calcium fluoride precipitate has been filtered and collected, the x'css calcium (II) is titrated with EDTA. The titration requires 24.20 ml of 0.0500 M EDTA. Calculate the % NaF in the sample. a. 31.38% b. 31.83% c. 33.18% d. 33.81% 11. Limestone (CaCO3) can be decomposed in a furnace to yield CaO(s) and CO2(g).If the furnace used a water filter as a purification method to trap emitted gases, what would happen to the pH of the water overtime? a. Increase b. decrease c. remain the same d. equal to 1 For numbers 12 and 13, Lactase, also known as B-galactosidase, catalyzes the hydrolysis of lactose to produce and galactose from milk and whey. Experiments are carried out to determine the kinetic parameters for enzyme. The initial rate data are as follows. Lactose Concentration (mol/L) 2.500 2.270 1.840 1.850 1.250 0.730 0.460 0.204 Reaction Velocity (mol/L-min) 1.940 1.910 1.850 1.800 1.780 1.460 1.170 0.779 12. Calculate Vmax using Lineweaver-Burk Plot. a. 1.11 mol/l-min b. 2.22 mol/L-min c. 3.33 mol/L-min d. 4.44 mol/L-min 13. Calculate Km using Lineweaver-Burk Plot a. 0.18 mol/L b. 0.28 mol/L 184 c. 0.38 mol/L d. 0.48 mol/L 14. In solution, glucose exists as: a. The open-chain form only b. The cyclic hemiacetal form only c. The cyclic acetal form only d. An equilibrium mixture of the open-chain form and cyclic acetal forms e. An equilibrium mixture of the open-chain form and cyclic hemiacetal forms. 15. A 550.0 mg sample is analyzed for aluminum (III) by adding 50.00 ml of 0.0510 M EDTA and back-titrating the x'css EDTA with 14.40 ml of 0.0480 M Zinc (II). Calc. the % aluminum in the sample a. 19.2 % b. 9.21% c. 12.9% d. 9.12% 16. What is the assumption and model used in cell kinetics? a. Structured, Distributed b. Unstructured, Distributed c. Structured, Segregated d. Unstructured, Segregated 17. A 0.3284 g sample of brass (contg. Lead, zinc, copper and tin) was dissolved in nitric acid. The sparingly soluble SnO2 x 4H2O was removed by filtration, and the combined filtrate and washings were then diluted to 500.00 ml. A 10.00 ml aliquot was masked with thiosulfate; the lead and zinc were then titrated with 27.67 ml of the EDTA sol'n. Cyanide ion was used to mask the copper and zinc in a 100.00 ml aliquot; 10.80 ml of the EDTA sol'n was needed to titrate the lead ion. Determine % Cu in the brass sample. a. 23.92% b. 29.32% c. 50.67% d. 50.76% 18. From no. 17, determine the % of tin by difference. a. 23.92% b. 29.32% c. 50.67% d. 50.76% 19. A 1.20 g sample of a mixture of sodium hydroxide and sodium carbonate with inert impurity is dissolved and titrated cold with 0.50N HCl. With phenolphthalein as the indicator, the solution turns colorless after the addition of 30.0mL of the acid. Methyl orange is then added, and 5.0mL more of the acid are required for the color to change to pink. What is the percentage of sodium carbonate in the sample a. 22.08% b. 32.11% c. 45.67% d. 41.67% 20. What is the normality of a solution of potassium permanganate if 40.0mL will oxidize 0.30g of sodium oxalate? a. 0.22 b. 0.06 c. 0.34 d. 0.59 185 21. Beaker A contains 0.1L of a 0.20M KOH solution; beaker B contains 0.1L of a 0.20 M HCl solution. The contents of the two beakers are thoroughly mixed together in a sufficiently large third beaker. Calculate the molarity of the resulting salt solution. a. 1M b. 0.001M c. 0.01M d. 0.1M 22. As a consulting engineer, you have been contracted to modify an existing control device used in fly ash removal. The federal standards for emissions have been changed to a total number basis. a. 1.856 x 10-8 gr b. 2.856 x 10-8 gr c. 3.856 x 10-8 gr d. 4.856 x 10-8 gr 23. Does the unit meet the effluent standard of 105.7 particles/ft3 a. The emission meets the standard b. The emission doesn't meet the standard c. The emission conditionally meet the standard d. There is not enough data 24. A sample of 500 mL of Genesee River was collected from just below the brewery. Three mL of the river water sample is diluted to 300mL, aerated and seeded. The DO content was 8.2 mg/L initially. After 5 days, the DO content had dropped to 6.7 mg/L. The second sample was obtained 60 days later and retested in identical fashion. The initial DO was 8.3 mg/L and after 5 days, dropped to 6.4 mg/L. What is the difference between the ultimate BOD of the two sample? Use k = 0.23/day. a. 48.54 mg/L b. 58.54 mg/L c. 68.54 mg/L d. 78.54 mg/L 25. Marijuana is the most commonly used illegal drug in the United States and in the World, and was a well-established medicine until it was federally criminalized in 1937. What is the chemical responsible for most of marijuana's psychological effects? a. Octanitrocubane c. Cisplatin b. Tetrahydrocannabinol d. Terapthalic acid 26. What is the percentage of the total acid expressed as acetic acid in a sample of vinegar if 3.00 g of vinegar require 20.5 mL of 0.115N KOH solution for an endpoint with phenolphthalein indicator? a. 3% b. 4.7% c. 4.3% d. 11% 27. Which of the following is the minimum information necessary for calculating the molality of a solution? a. The mass of the solute and the volume of the solvent b. The mass of the solute, the volume of the solvent, and the density of the solvent 186 c. The mass of the solute, the volume of the solvent, and the molecular mass of the solute. d. The mass of the solute, the volume of the solvent, the molecular mass of the solute, and the density of the solvent 28. A vacuum manifold was calibrated using Boyle's law. A 0.503-dm^3 flask containing dry nitrogen at 746 torr was attached to the manifold, which was at 13 mtorr. After the stopcock was opened and the system allowed to reach equilibrium, the pressure of the combined system was 273 torr. Assuming isothermal conditions, what is the volume of the manifold? a. 0.728 dm^3 b. 0.872 dm^3 c. 0.827 dm^3 d. 0.782 dm^3 29. Which of the following is a TRUE statement? a. A carbon atom is larger than a hydrogen atom b. Citric acid cycle is also called as carboxylic acid cycle c. Cardiolipids are a group of lipids found in heart muscles d. Sanger dideoxy method uses carbon reactions 30. Sulfuric acid in water dissociates completely into H+ and HSO-4 ions. The HSO-4 ion dissociates to a limited extent into H+ and SO4 -2. The freezing point of 0.1000 m solution of sulfuric acid in water is 272.76 K. Calc. the molality of SO4 -2 in the solution, assuming ideal solution behavior. a. 0.0079 b. 0.097 c. 0.0097 d. 0.079 31. The process by which the genetic information encoded in DNA is read and used to synthesize RNA in the nucleus of the cell a. Transfer RNA c. Transamination b. Trasncription d. Translation 32. How many products might be formed on chlorination of m-xylene? a. 1 b. 2 c. 3 d. 4 33. An aqueous solution of glucose behaves as an aldehyde because: a. It is hydrolysed by water to the free aldehyde b. It is a ketoe, but is in equilibrium with the aldehyde form c. Glucose is actually a cyclic aldehyde d. Its cyclic hemiacetal, the predominant form, is in equilibrium with the free aldehyde form e. It can be oxidized with periodic acid. 34. The difference between heat capacity at constant volume and heat capacity at constant pressure is the heat energy may be supplied (for constant) to increase a. Internal energy c. pressure changes b. volume changes d. temperature changes 187 35. Ozonolysis (O3 in CH2Cl2) of compound A under reducing conditions (Zn /acetic acid) gives formaldehyde, 2-butanone, and compound B. Catalytic hydrogenation (H2/Pd) of A gives 2,7-dimethylnonane. What is a possible structure for compound A? a. 2,7-Dimethyl-2,8-nonadiene c. 2,7-Dimethyl-1,6-nonadiene b. 2,7-Dimethyl-1,8-nonadiene d. 2,7-Dimethyl-1,7-nonadiene 36. What weight of sample of impure oxalic acid should be taken for titration by 0.50N NaOH so that the percentage of H2C2O4·2H2O will be twice the burette reading? a. 1.57 g b. 2.33 g c. 2.11 g d. 1.02 g 37. What is the sequence of reagents that will accomplish the synthesis of the following aromatic amine from benzene? a. CH3Cl, AlCl3; HNO3, H2SO4; H2 b. CH3Cl, AlCl3; HNO3, H2SO4; Fe, HCl; NaOH c. HNO3, H2SO4; Fe, HCl; NaOH; CH3Cl, AlCl3 d. HNO3, H2SO4; CH3Cl, AlCl3; Fe, HCl; NaOH 38. This type of spectroscopy is mainly used to tell functional groups within a compound. Older versions require special salt plates, but newer technology has made them obsolete. The "fingerprint region" in the readout is only useful for those who have studied this method extensively, and isn't very useful for beginners. a. Nuclear Magnetic Resonance c. Infrared Spectroscopy b. X-ray fluorescence d. Gas chromatography-mass spectroscopy 39. How may stereoisomers of 3-bromo-2-butanol, CH3CH(OH)CHBrCH3, exist? a. 3 b. 1 c. 4 d. 2 40. A "strong water"| as defined from DAO 35 refers to the water whose initial BOD value before treatment is equal to greater than a. 500 b. 1000 c. 3000 d. 5000 e. 250 41. The biological decomposition of organic matter accomplished by the production of foul smelling product associated with inadequate oxygen. a. Assimilative capacity b. Eutropication c. Phosphorylation d. Putrefaction 188 42. The Philippine Starch Corporation prepares pharmaceutical glucose from cornstarch by enzyme hydrolysis. It was observed that when the starch concentration of the slurry was 5%, the rate of concentration of starch to glucose was 0.04 kg/s. When the starch concentration was made 10%, the turnover rate was 0.07 kg/s. The maximum production level of glucose that can be reasonably be obtained per shift of 8 hours is a. 8064 kg b. 7064 kg c. 6064 kg d. 5064 kg 43. Which of the following statements correctly describes the general reactivity of alkynes? a. An alkyne is an electron-rich molecule and therefore reacts as a nucleophile b. The sigma bonds of alkynes are higher in energy than the pi bonds and are thus more reactive c. Unlike alkenes, alkynes fail to undergo electrophilic addition reactions d. Alkynes are generally more reactive than alkenes 44. Which statements apply to an SN1 reaction? I. The rate of limiting of the reaction involve the alkyl halide and the the nucleophile II. The order of reactivity is methyl>1>2>3 III. The rate limiting step of the reaction involves only the alkyl halide IV. There is an intermediate carbocation a. I,II b. III, IV c. I, IV d. III 45. Arrange the compounds in the order of increasing solubility in water I. CH3CH2CH2CH2OCH3 II. CH3OCH3 III. CH3OCH2CH2OCH3 IV. CH3CH2CH2CH2CH2OH a. I,III,II,IV b. III,I,IV,II c. I,IV d. IV,I,III,II 46. Which of the following is the most important progestin? a. Androsterone b. Estrone c. Progesterone d. Testosterone 47. The Del Factor to reduce the number of cells in a fermenter from 1010 viable organisms to one is: a. 21 b. 23 c. 25 d. 27 48. Which reaction does not lead to 3-methyl-3-hexanol? 189 a. b. c. d. 2-butanone + propylmagnesium bromide 3-hexanone + methylmagnesium bromide 2-pentanone + ethylmagnesium bromide 3-pentanone + ethylmagnesium bromide 49. Which of the following does not belong to the group? a. Aspirin b. Naprosyn c. Tylenol d. Kremil-S 50. Which statement does not describe a transition state? a. Possesses a definite geometry b. Maximum on the potential energy diagram c. Structure can be determined experimentally d. Cannot be isolated 51. The building blocks of proteins: a. Carbohydrates b. Lipids c. Nucleic acids 52. Benzyl penicillinic acid is also known as a. Penicillin A b. Penicillin G c. Penicillin B d. Amino Acids d. Penicillin H 53. The most general method for preparing alcohol is a. Reduction of carbonyl group b. Separation of carbonyl group c. Oxidation of carbonyl group d. Hydrogenation of carbonyl group 54. The partial double bond character of the peptide bond a. Makes the link between two amino acids planar b. Restricts free rotation about the bond c. Is a result of resonance hybridization d. All of these choices 55. In the systematic nomenclature of peptides, which is given first? a. The residue that comes first alphabetically b. The residue with the largest R-group c. The C- terminal amino acid residue d. The N-terminal amino acid residue 56. A balloon has a mass of 0.5 g when completely deflated. When it is filled with an unknown gas, the mass increase to 1.7 g. You noticed on the canister of that unknown gas that it occupies a volume of 0.4487 L at a temperature of 50 oC. You note the temperature in the room is 25 oC. Give the possible name of the unknown diatomic gas. Assume all the canister contents have been emptied and the condition is held at 1 atm pressure. Use oC + 273.15 K for all the temperature conversion and R=0.08206 Latm/Kmol. a. Br2 b. Cl2 c. O2 d. N2 190 57. A 1.20g sample of a mixture of sodium hydroxide and sodium carbonate with inert impurity is dissolved and titrated cold with 0.50N HCl. With phenolphthalein as the indicator, the solution turns colorless after the addition of 30.0mL of the acid. Methyl orange is then added, and 5.0mL more of the acid are required for the color to change to pink. What is the percentage of NaOH in the sample? a. 22.08 % b. 32.11% c. 45.67% d. 41.67% 58. The reaction C2H5ONa + C2H5I a. Kolbe's Synthesis b. Wurtz's Synthesis c. Williamson's synthesis d. Grignard's Synthesis C2H6OC2H5+NaI is known as 59. Cetane number indicates the amount of a. Heptane b. 2,2,4-trimethylnaphthalene c. 1-methylnaphthalene d. n-hexadecane 60. A 1-month-old male showed abnormalities of the nervous system and lactic acidosis. Enzyme assay for pyruvate dehydrogenase (PDH) activity on extracts of cultured skin fibroblasts showed 5% of normal activity, with a low concentration (1 x 10-4 mM) of thiamine pyrophosphate (TPP), but 80% of normal activity when the assay contained a high (0.4 mM) concentration of TPP. Which one of the following statements concerning this patient is most correct? a. Elevated levels of lactate and pyruvate in the blood reliably predict the presence of PDH deficiency b. The patient is expected to show disturbances in fatty acid degradation c. A diet consisting of high carbohydrate intake would be expected to be beneficial in this patient d. Alanine concentration in the blood is expected to be less than normal e. Administration of thiamine is expected to reduce his serum lactate concentration and improve his clinical symptoms 61. Which of the following statement is not valid? a. Above the critical temperature, the given substance has a single phase occupying the entire volume of the container b. The Tc of O2 is 155 K, this means that it is impossible to prodce O 2 if its T is above 155K c. To liquefy a given substance at Tc, high pressure must be applied d. Liquid and vapor exist at Tc and both phases are distinct 191 62. In 1932, James Chadwick bombarded a thin sheet of beryllium with alpha particles, and paved way for his discovery of this very small particles. What is this small particle? a. Electron b. Proton c. Neutron d. Atom 63. Which of the following is not true about acids? a. Sour tastes b. Reacts with metal to produce gas c. Changes litmus from blue to red d. Aqueous solutions do not conduct electricity 64. The 5-day BOD of domestic sewage is 200 ppm and its removal rate constant K is 0.23/day. What is the ultimate BOD in ppm? a. 29.27 ppm b. 60.1 ppm c. 292.7 ppm d. 400 ppm 65. An open chamber rest on the ocean floor in 50 m of sea water (SG=1.03). The air pressure in kilopascals that must be maintained inside to exclude water is nearest to a. 318 b. 431 c. 505 d. 661 66. A small bubble rises from the bottom of a lake, where temperature and pressure are 8 deg C and 6.4 atm, to the water's surface, where the temperature is 25 deg C and pressure is 1 atm. Calculate the final volume of the bubble if its initial volume was 2.1mL. a. 10 ml b. 12 ml c. 14mL d. 16 ml 67. A 7.5 m3 chemostat operating at 75% capacity is producing biomass from a glucose feed at a volumetric flow rate of 46.9 L/min. The specific growth rate of the organism is: a. 0.373/h b. 0.0083/h c. 0.5/h d. 0.006/h 68. Sodium azide is used in some automobiles air bags. The impact collision decomposes the sodium azide to sodium and nitrogen gas. Calculate the volume of the nitrogen gas generated during impact at 85 deg C and 812 mmHg from 50.0g sample of sodium azide. a. 12L b. 32 L c. 43 L d. 16 L 69. All of the following factors increase the strength of van der Waals forces between molecules except by an a. Increase in the molecular weight of the molecules b. Increase in the number of atoms in the molecules c. Increase in the number of electrons in the molecules d. Increase in the ionic strength of the molecule 192 70. Robert Boyle became famous due to his studies in gas collisions. What is the nationality of Boyle? a. Polish b. Irish c. English d. American 71. A flammable gas made up only of carbon and hydrogen is found to effuse through porous barrier in 3.50 min. Under the same conditions of temperature and pressure, it takes an equal volume of chlorine gas 7.34 mins to effuse through the same barrier. Calculate the molar mass of the unknown gas. a. 12 g/mol b. 16 g/mol c. 18 g/mol d. 24 g/mol 72. Cisplatin, whose formula is PtCl2(NH3)2 is an a. Anti-histamine drug b. Anti-inflammatory c. Anti-cancer drug d. Antiseptic drug 73. A given amount of electric charge deposits 2.159 gram of silver from an Ag+ solution. What mass of copper from a Cu+2 solution will be deposited by the same quantity of electric charge? Atomic masses: Ag = 107.87 g/mol; Cu = 63.5 g/mol a. 0.635 gram b. 0.356 gram c. 0.535 gram d. 0.335 gram 74. Which of the following compounds can undergo the aidol reaction a. Benzaldehyde b. 2,2,6,6-tetramethylcyclohexanone c. Formaldehyde d. 2,2-dimethylcyclohexanone 75. Which of the following is a TRUE statement/ a. A carbon atom is larger than a hydrogen atom b. Citric acid cycle is also called as carboxylic acid cycle c. Cardiolipids are a group of lipids found in heart muscles d. Sanger dideoxy method uses carbon reactions 76. Which functional group will cause an IR absorption of 3500/cm? a. Alkyne b. Alkane c. Ketone d. Alcohol 193 77. Glutathione removes potentially harmful oxidants in human body and is a common whitening agent among Filipinos. How many carbon atoms does glutathione have? a. 10 b. 12 c. 7 d. 15 78. Which of the following is an aldohexose? a. Glucose b. Fructose c. Ribose d. Sedoheptulose 79. How much money was appropriated for the initial implementation of the Philippine Clean Air Act of 1999? a. 500 Million pesos b. 750 Million pesos c. 600 Million pesos d. 1 Billion pesos 80. Which of the following is the most acidic? a. Ethanol b. Methanol c. Butanol d. Phenol 194 ANSWER KEY PRELIM EXAMINATION 1. B 2. A 3. B 4. B 5. D 6. C 7. A 8. C 9. A 10. C 11. B 12. B 13. C 14. E 15. D 16. B 17. A 18. D 19. A 20. B 21. D 22. A 23. B 24. B 25. B 26. B 27. D 28. B 29. C 30. C 31. B 32. C 33. D 34. B 35. C 36. A 37. B 38. C 39. C 40. C 41. D 42. A 43. A 44. B 45. B 46. C 47. B 48. D 49. D 50. C 51. D 52. B 53. A 54. E 55. D 56. B 57. E 58. C 59. D 60. E 61. D 62. C 63. D 64. C 65. C 66. C 67. C 68. B 69. D 70. C 71. B 72. C 73. A 74. A 75. C 76. D 77. A 78. A 79. B 80. D 195 PRELIMINARY EXAMINATION SOLUTIONS 10. (50.00)(0.1000) – (24.20)(0.0500) = 3.70 mole Ca = 12. (3.970)(2)(41.99)(100) 1000.0 = 31.83 % NaF Using Lineweaver-Burk Plot; Using calculator, Mode>Stat>A+Bx Input (x) = 1/Concetration Input (y) = 1/ velocity Get Vmax by: 1/A Vmax = 2.22 mol/L-min 13. 15. From number 12; Get Km by: B/A Km = 0.38 mol/L Al3+ + Y4- AlY- 0.051 mol/L EDTA x Zn2+ + Y4- 50 1000 L = 2.55x10-3mol EDTA ZnY214.40 0.0480 mol/L Zn2+ x 1000 1mol Y4− L Zn2+ x 1mol Zn2+ = 6.912x10-4mol EDTA mol EDTA reacted w/ Al3+ = (2.55x10-3) – (6.912x10-4) = 1.8588x10-3 mol EDTA = mol of Al3+ Mass Al3+ = 1.858x10-3 x %Al3+ = 19. 50.1504 550 0.5mol/L HCl x % Na2CO3 = 196 26.98g 1mol x 1000mg 1g x 50.1504mg x 100 = . % 5 1000 Lx 0.264975 1.2 1mol Na2CO3 1mol HCl x 100 = 22.08% x 105.99g Na2CO3 1mol Na2CO3 = 0.264975g Na2CO3 20. KMnO4 + Na2C2O4 1mol Na2C2O4 0.3g Na2C2O4 x Molarity = NaMnO4 + K2C2O4 134g Na2C2O4 2.2388x10−3mol KMnO4 40ml x 1L 1000mL 1mol KMnO4 x 1mol Na2C2O4 x = 2.2388 x10 − 3 mol KMnO4 = 0.0560 M Normality = 0.0560M x 5 = . 21. KOH + HCl 0.02 mol 0.02 mol 0 0 KCl + H2O 0 0 0.02 0.02 0.02 mol Molarity = (0.1+ 0.1)L = . 22. Data for the unit are given below. Average particle size, dp = µm (assume constant) Particle specific gravity = 2.3 Inlet loading = 3.0 gr/ft3 Efficient (mass basis) = 99% m = 1.856 x 10-8 gr 24. 1st BOD testing: After 60 days Do = 8.2 mg/L Do = 8.3 mg/L Df = 6.7 mg/L Df = 6.4 mg/L BOD5 = Lo = (8.2−6.7)mg/L 3/300 1−e^(−kt) BOD5 1−e^(−0.23x5) 150 Lo = 219.50 mg/L = 150 BOD5 = Lo = (8.3−6.4)mg/L 3/300 = 190 1−e^(−kt) BOD5 1−e^(−0.23x5) 190 L0 = 278.04 mg/L 197 ΔLo = 278.04 mg/L – 219.50 mg/L ΔLo = 58.54 mg/L 26. CH3COOH + KOH 0.115mol/L KOH x 20.5 1000 0.1416 % CH3COOH = 28. CH3COOK + H2O 3 Lx 1mol CH3COOH 1mol KOH x 60.06g CH3COOH 1mol CH3COOH = 0.1416g CH3COOH x 100 = . % ΔP1V1 = P2V2 (0.503)(746 – 273) = 273 (V2) V2 = 0.87149 dm3 64. 5-day BOD = 200 mg/L (due to carbon only); k=0.23/day L(5)= L0 [1-e(-k*5)] = 2000 mg/L= L(0) [1-e(-0.23*5)] Ultimate BOD Lo = 292.6 mg/L 65. p = ywaterh = (SG)(ywater)(h) P = (1.03)(9.81)(50) = 505 kPa 66. P1V1T2 = P2V2T1 (6.4atm)(2.1mL)(298.15K) = (1atm)(V2)(281.15K) V2 = 14.25mL 68. 2NaN3 → 2Na+3N2 (balanced equation) 1 mole NaN3 3 moles N2 50 g (64.99 g NaN3) = 0.769 moles NaN3 (2 moles NaN3) = 1.1535 moles N2 PV = nRT 198 812 mmhg (760 mmhg)(V) = 1. 1535 moles N2 (0.08206 L−atm mol−K)(85 + 273.15) V = 31.73 L = 32 L 71. r1 r2 t M = t2 = √M2 1 3.50 min 7.34 min 1 M = √ 35.43 g mol M = 8.06 g/mol M = 8.06 g/mol (2) = 16 g/mol 73. Silver moles = given mass / molar mass = 2.158 / 107.9 = 0.0200 moles. of silver. If you we have 0.02 moles of Ag, we will only get 0.01 moles of Cu n = Mass / atomic mass n = 0.01 molar mass = 63.5 0.01 = x / 63.5 x = 0.635 grams of Cu 199 MIDTERM EXAMINATION CHEMICAL ENGINEERING 1. Particle diameter representation which is defined as the width of the minimum square aperture through which the particle will pass. a. Feret's diameter c. Sieve diameter b. Martin's diameter d. Projected area diameter 2. Equivalent diameter of a particle which is referred to the average distance between pairs of parallel tangents to the projected outline of the particle. a. Feret's diameter c. Sieve diameter b. Martin's diameter d. Projected area diameter 3. Which of the following is not a standard in a particle size distribution using sieves? a. Tyler series c. US series ATM b. API d. all are standards 4. In Moh's scale, which is the hardest among the materials given? a. Apatite c. Feldspar b. Quartz d. Topaz 5. A crushed material of certain ore has 3'' – diameter particle and has density of 170lb/ft. If the specific surface area ratio is 10, what is the specific surface in cm² per g of ore? a. 2.89 b. 28.9 c. 7.2 d. 72 6. The energy required to reduce the size of a certain ore from 1cm to 0.3cm is 11kJ/kg. What is the power requirement to reduce the same set of material from 0.1cm to 0.01cm assuming Kick's law apply? a. 21 c. 423 b. 91 d. None of the choices 7. What is the sphericity of cylinder assuming that the equivalent length is equivalent to its height? a. 0.806 c. 0.874 b. 0.857 d. 1 8. In an analysis of a certain crushed material, the total surface area of a certain fraction of a 5kg sample that passed through a 7 mesh sieve but was caught on a 9 200 mesh sieve is 7.88m². If the density of the material is 1050 kg/m³ and the shape factor is 1.75, find the fraction. a. 34% b. 38% c. 42% d. 52% 9. What is the sphericity of a cylinder with L/D ratio of 1? a. 0.806 b. 0.857 c. 0.874 d. 1 c. 0.874 d. 1 10. What is the sphericity of a cube? a. 0.806 b. 0.857 11. Find the width of an apron conveyor without skirts whose capacity is 56tons/hr at a speed of 50rpm handling solids with density of 50lb/cuft. a. 36 inches b. 38 inches c. 40 inches d. 52 inches 12. A type of a gas-solid separator employing centrifugal force. a. elutriator c. centrifuge b. cyclones d. none of these 13. The energy required per unit mass to grind limestone particles of very large size to 100mm is 12kWh/ton. An estimate (using Bond's law) of the energy to grind the particles from a very large size to 50mm is a. 18kWh/ton b. 10kWh/ton c. 15kWh/ton d.12kWh/ton 14. A material is crush in a Blake Jaw Crusher and the average size of particle reduces from 50mm to 10mm with the consumption of energy at the rate of 13kW(kg/s). The consumption of energy needed to crush the same material of an material of an average size 75mm to an average size 25mm assuming Kick's Law applies is a. 8.88kW(kg/s) c. 4.66kW(kg/s) b. 8.08kW(kg/s) d. 4.33kW(kg/s) 15. Saturated steam at 110ºC is available and the temperature in the condenser is 43ºC. Specific heat of the solutions may be taken is constant at 4 J/g ºC. The overall-heat transfer coefficient is 2840W/m² ºC. Determine the steam consumption, in kg/hr. a. 3400 b. 4700 c. 5800 d. 6500 16. Refer to item no. 15, how many square meters of heating surface are required? a. 15 b. 13 c. 11 d. 9 For numbers 17 to 18. Determine the boiling point rise for the following solutions of biological solutions in water. 201 17. A 30 wt% solution of citric acid in water boiling at 220ºF a. 3.4ºF b. 1.8ºF c. 2.2ºF d. 4.5ºF 18. A 40 wt% solution of sucrose in water boiling at 220ºF a. 1.4ºF b. 2.1ºF c. 3.2ºF d. 4.9ºF 19. The rate of increase of the number of bacteria under certain condition is proportional to the number of bacteria. If the number doubles in four hours, how much increase in number of bacteria can be expelled after 12 hours? a. 2 b. 4 c. 6 d. 8 20. A second order reaction involving reactants initially present at 0.10moles/L is found to be 20% complete in 40minutes, when the reaction is 25ºC, and 40% complete in 35 minutes, when the reaction is 50ºC. What is the activation energy for this reaction in cal/mol? a. 2700 cal/mol b. 8500 cal/mol c. 1020 cal/mol d. 5530 cal/mol 21. In a first order reaction the time required to reduce the concentration of reactant from 1mol/L to 0.5mol/L will be ____________ that required to reduce it from 10mol/L to 5mol/L in the same volume. a. more than b. less than c. same d. data sufficient 22. If a first order reversible liquid reaction A ↔ B is conducted in a batch reactor. The initial concentrations are CA0 = 0.5gmol/L and CB0 = 0. After 8 minutes, the fractional conversion of A is 1/3 and at equilibrium, the fractional conversion of 2/3. Find the equilibrium constant. a. 1 b. 2 c. 3 d. 4 23. A gaseous reaction, A → 2B + C takes place isothermally in a constant pressure reactor. Starting with gaseous mixture containing 50% A, the ratio of final to initial volume is found to be 1.6. Calculate the percentage conversion of A. a. 30 b. 50 c. 60 d. 74 24. Pick the wrong statement pertaining to space velocity of flow reactors. a. The unit space velocity is (time)−1 . b. The space velocity of 3 hr −1 means that the three reactor volumes of feed at specified conditions are being fed into the reactor every hour. 202 c. The space velocity of 3 hr −1 means that the one third reactor volume of feed at specified conditions are being fed into the reactor. d. None of these. 25. For liquid phase zero order irreversible reaction A → B, the conversion of A in a CSTR is found to be 0.3 at space velocity of 0.1min−1 . What will be the conversion for PFR with a space velocity of 0.2min−1 ? Assume that all the other operating conditions are the same for CSTR and PFR. a. 0.15 b. 0.30 c. 0.60 d. 0.90 For numbers 26-28: A homogenous liquid phase, A → R, −rA = kCA ² takes place with 50% conversion in a mixed reactor. 26. The value of space time a. 1/(2kCA0) b. 2/(kCA0) c. 1/(kCA0) d. 3/(kCA0) 27. What is the conversion if the reactor is replaced by one 6 times as large – all else remaining unchanged? a. 0.67 b. 0.75 c. 0.70 d. 0.79 28. 28. Calculate the conversion if the original reactor is replaced by a plug flow reactor of equal size – all else remaining unchanged? a. 0.67 b. 0.90 c. 0.88 d. 0.92 29. The separation of solid particles into several size fractions based upon the settling velocities in a medium is called a. settling c. flotation b. filtration d. classification 30. An apparatus in which particles settle in a liquid by gravitational or centrifugal force and are removed as a concentrated slurry. a. classifier b. thickener c. elutriator d. agitator 31. What is the absolute velocity of a real fluid at a surface? a. the same as the bulk fluid velocity b. the velocity of the surface c. zero. d. proportional to the smoothness of the surface 203 32. Which of the following sets of reversible processes describes an ideal Otto cycle? I. Adiabatic compression, constant volume heat addition, adiabatic expansion, constant volume heat rejection II. Isothermal compression, isobaric heat addition, isothermal expansion, isobaric heat rejection a. I only b. II only c. I and II in succession d. II and I in succession 33. Which of the following statements regarding Rankine cycles is false? a. Use of condensable vapor in the cycle increases the efficiency of the cycle b. The temperatures at which energy is transferred to and from the working liquid are less separated than in a Carnot cycle c. Superheating increases the efficiency of a Rankine cycle d. In practical terms, the susceptibility of the engine materials to corrosion is not a key limitation on the operating efficiency. 34. Which of the following is/are representation of a carnot cycle? a. I and II b. I and III c. II and III d. all of these 35. For which type of process is the equation dQ = TdS valid? a. Irreversible b. Reversible c. Isothermal d. Isobaric 36. The general energy equation for an open system involves the following terms: 204 I. Accumulation of energy IV. Transfer of energy in by mass flow II. Net energy transfer by work V. Transfer of energy out by mass flow III. Net energy transfer by heat a. I = -II + III + IV – V b. I = II + III + IV + V c. I = II + III + IV – V d. I = II – III – IV + V 37. Which of the following flow meters measure/s the average fluid velocity rather than a point or local velocity in a pipe? I. Venturi meter IV. Orifice meter II. Pitot tube V. Hot-wire anemometer III. Impact tube a. I and III b. III and V c. I and IV d. II and V 38. Consider the following two flows of water in the figure shown. What is the relation between the velocity at point 2 in I and II? a. V2(I) =V2(II) b. V2(I) =1/2 V2(II) c. V2(I) =2 V2(II) d. V2(I) =4 V2(II) 39. Which of the following describes a streamline? I. It is a mathematical concept II. It cannot be crossed by the flow III. It is a line of constant entropy a. I and II b. I and III c. II and III d. all of these 40. Calculate the terminal velocity of a steel ball, 2mm diameter and of density 7870kg/m³ in an oil of density of 900kg/m³ and viscosity 50mN-s/m². 205 a. 0.189m/s b. 0.289m/s c. 0.389m/s d. 0.489m/s 41. The thermodynamic equilibrium constant is unaffected by the following except: a. Pressure of the system c. velocity of the flow b. Presence or absence of inerts d. kinetics of the reaction 42. He pioneered the work of the first commercial steam turbine (5hp). a. George Herman Babcock c. Gustaf de Laval b. Stephen Wilcox d. John Barber 43. Power plants should operate on the following conditions: a. below 100,000kPa and below 600ºC c. above 100,000kPa and above 600ºC b. below 100,000kPa and above 600ºC d. above 100,000kPa and below 600ºC 44. The Diesel engine differs from the Otto engine because a. higher compression ratio c. low cut-off ratio b. lower compression ratio d. high cut-off ratio 45. Air is flowing at a steady rate of 0.0232 lb/sec through a straight tube having an inside diameter of 0.2 inch. At the first section, the air has a temperature of 70ºF and is under an absolute pressure of 0.2atm. The tube is heated and the net input power, between the first and second section, is 174 watts. The air at the second section is under an absolute pressure of 0.1atm. The average specific heat of the air is 0.24BTU/lb ºF. Calculate the temperature of the air leaving the second section. a. 63ºF b. 73ºF c. 83ºF d. 93ºF 46. A tank of relatively non-volatile oil is to be cooled from 200º to 100ºC by blowing cold air at 1 atm and 20ºC through it. How long will this process take if the air leaving the tank is always in thermal equilibrium with the oil? Assume that the air bubbles keep the oil well agitated. Data: Heat capacity of oil = 0.81 cal/(g ºC) Air rate (1 atm and 20ºC) = 100cfm Capacity of the oil tank = 1,000 gal Sp. Gr of oil = 0.88 a. 4,550 min c. 6,550 min b. 5,550 min d. 7,550min 47. A very dilute gas mixture of sulfur dioxide in air is contacted with water in a 25 mm ID wetted wall column at 20ºC and 1 atm. The velocity of gas mixture is 2.2m/s. Determine the friction factor. 206 a. 0.01 b. 0.003 c. 0.006 d. 0.008 48. The rotational speed in RPM that you could recommend for a ball mill, 1200 mm in diameter charged with 75 mm balls is a. 30 b. 60 c. 10 d. 50 49. In countercurrent liquid-liquid extraction, the maximum concentration of solute in extract layer a. Is that corresponding to equilibrium with the incoming feed b. Is less that the concentration corresponding to equilibrium with the incoming feed c. Can be increased than the obtained in (a) above by using raffinate reflux d. none of the above 50. An isobaric steam generating process starts with saturated liquid at 143kPa. The change in entropy is equal to the initial entropy. Not all of the liquid is vaporized. What is mostly nearly the change in enthalpy during the process? a. 110kJ/kg b. 270kJ/kg c. 410kJ/kg d. 540kJ/kg 51. A current of 200A is passed through a stainless steel wire (k =22.5, SI units) with a diameter of 5mm and length of 1 m. The electrical resistance of the wire is 0.1ohm. Estimate the temperature at the center of the wire if the outer surface temperature is held at 114ºC a. 114.5 degC b. 116.3 degC c. 128.4 degC d. 134.7 degC 52. What is the BPR of a 30% NaOH solution at an evaporator pressure of 3.722psia? a. 17 degF b. 25 degF c. 29 degF d. 33 degF 53. A system consists of moist air and water inside a closed container. What is this system's degree of freedom? a. 0 b. 1 c. 2 d. 3 54. A newly designed air-conditioning unit has a capacity of 3140 watts and an input rating of 735 watts. If this machine is operated as heat pump, its COP is a. 4.27 b. 5.27 c. 4.44 d. 5.44 55. The evidence that the solute does not freeze with the solvent is that a. the first crystals formed are precipitates of the solute 207 b. the crystals formed could clearly be seen as that of the solution c. the freezing point of the solution that remains a liquid is getting lower and lower as freezing proceeds d. the freezing point asymptotically a constant value. 56. What does the dashed curve in the figure represent? a. the solidus line b. an isotherm c. the saturated liquid line d. the saturated vapor line 57. For the Carnot cycle shown, helium is the gas used with a specific heat ratio, k, of V T P 5/3. Given that VB = 2 and TA = 1.9, calculate PC . A D a. 0.0633 c. 0.1800 b. 0.1000 d. 0.2620 A 58. Pick out the wrong statement. a. entering velocity of the liquid in the tubes of natural circulation evaporators is in the range of 0.3 to 0.9m/s. b. duhring's plot is used for calculating the concentration of solution 208 c. the value of hydrostatic head increases with increase in vacuum in the effect in a multiple effect evaporator system d. In a multiple effect evaporator system, the number of effects is limited by the total boiling point rise. 59. Which of the following has the minimum absorptivity? a. Refractory bricks b. Aluminum foil c. Iron plates d. Coal dust 60. To reduce the tube side pressure drop for the same flow rate, the heat exchanger recommended is a. 1-1 heat exchanger b. 1-2, heat exchanger c. 2-4, heat exchanger d. 3-2 heat exchanger 61. Drying operation under vacuum is carried out to a. reduce drying temperature b. dry those materials which have very high unbound moisture content c. dry materials having high bound moisture content d. increase drying temperature 62. Pick out the wrong statement. a. Packed towers are preferred for vacuum operation, because the pressure drop through the packing is less and they (packings) also lessen the possibility of tower wall collapse. b. Packed towers are preferred over plate towers for handling corrosive and foamy liquids. c. due to uneven supply and improper distribution of liquid, problem of channeling, loading & flooding is generally encountered in packed towers. d. diameter of randomly packed towers is normally more than 1.2m. 63. For zero order reaction, the concentration of product increases with the a. increase of reaction time c. increase in initial concentration b. total pressure d. decrease in total pressure 209 64. Which of the following curves shows the effect of temperature on the gas-solid adsorption at a given pressure? a. Freundlich adsorption isotherm c. Langmuir adsorption isotherm b. Adsorption isobar d. None of these 65. Pick out the wrong statement. a. In a continuous flow reactor, uniform concentration can not be maintained throughout the vessel even in a well agitated system b. In a continuous flow reactor, both the reactants and products flow out continuously. c. In a semi-batch reactor, one reactant is charged otherwise, while the other reactant is fed continuously. d. In a batch reactor, which is exclusively used for liquid phase reactions; temperature pressure and composition may vary with time. 66. Which of the following denotes the effect of compressibility in fluid flow? a. Weber number c. Reynolds number b. Euler number d. Mach number 67. Pick out the wrong statement pertaining to the design of the bubble cap tray of a distillation column to give stable operation and even vapor distribution. a. the dimensionless ratio of liquid gradient to pressure drop head caused by the bubble cap assembly should be less than 0.4. b. the pressure drop due to the caps and slots and the static submergence should be as high as practicable for reasonable operation c. Tendency towards stable operation is increased by increasing the skirt clearance of the caps, lowering the rate of liquid flow per unit plate width or increasing the spacing between the caps. d. none of these 68. It is the procedure in which a fraction of the fees to a process unit is diverted around the unit and combined with the output stream from the unit. a. Recycle b. Bypass c. Purge d. Reflux 69. A storage tank of demineralized water has a holding capacity of 1800m3 up to an overflow point. The DM water having silica content of 0.005mg/L is flowing into a tank at a rate of 25L/s. The outflow from a tank to the high pressure boiler is 210 25L/s. With time, the quantity of DM water deteriorates and the silica content rose up to 0.02mg/L. Assuming that the inflow and the outflow remains constant, determine the time in hrs required for the silica content in the storage tank to increase to 0.01mg/L. a. 76.6 b. 6.77 c. 7.66 d. 66.7 e. 8.11 70. One gram of a magnesium-aluminum alloy was reacted with excess muriatic acid to form magnesium chloride, aluminum chloride and hydrogen gas. Hydrogen gas collected over mercury at 0ºC occupied at 2.835L at 39.26kPa. Find the %Al in the alloy. a. 44 b. 56 c. 54 d. 46 For numbers 71 and 72, The fresh feed to the process was 0.5kmol/hr of O2 and an excess methanol. All of the O2 reacts in the reactor. Formaldehyde and water are removed from the product stream first, after which H2 is removed from the recycled methanol. The recycle flow rate of methanol was 1kmol/hr. The ratio of methanol reacting by decomposition to that by oxidation was 3. 71. Calculate the per pass conversion in % of methanol in the reactor a. 60 b. 70 c. 80 d. 90 72. Calculate the fresh feed rate (in kmol/hr) of methanol a. 3 b. 3.5 c. 4 d. 4.5 73. Natural gas containing 80% CH4, 15% C2H6, and 5% C3H8 is burnt with 50% excess air. Assuming that 90% of the carbon in the hydrocarbons are converted to CO2 and the rest to CO, determine the %mol of H2O produced in stack gas. a. 5 b. 5.5 c. 6 d. 6.5 e. 2.25 74. A solid fuel consisting of 90.04% C, 0.79% S, 1.2%N with no ash and moisture undergoes combustion with excess air. Analysis of stack gas shows 10.83% CO2, 1.08% CO, 0.22%H2, 79.9%N2 and 7.97%O2. Calculate the ultimate H in the solid fuel. a. 5.07 b. 8.04 c. 2.9 d. 5.39 75. The most matured coal out of the following is a. Bituminous b. Semi-anthracite c. Sub-bituminous d. Lignite 76. Gross calorific value will be equal to the net calorific value for 211 a. H2 b. C2H2 c. CO d. C2H6 77. A fluid flow (Cp = 4.0kJ/kg-K) flowing at 0.5kg/s is to be heated from 18ºC to 30ºC in a medium sized 2-3 STHE using another fluid (Cp = 1.20kJ/kg-K), which enters on the shell side of the exchanger at 71ºC and to leave at 62ºC. The overall heat transfer coefficient is 50W/m²-K. What is the flow rate of the other fluid? a. 2.2 b. 2.0 c. 3.0 d. 2.5 78. In the previous problem, what is the surface are for heat transfer? a. 8.8 b. 6.61 c. 9.72 d. 11.55 79. Because of fouling due to prolonged use, the exit temperature of the cold fluid becomes 28º a. 0.00669 b. 0.00103 c. 0.000931 d. 0.00483 80. What is the simplest type of heat exchanger? a. Double-pipe HE c. Cross-flow HE b. Shell-and-tube HE d. Finned-type HE 81. In a distillation column, the bottom section has the following characteristics, a. highest temperature c. both a and b b. highest pressure d. neither a nor b 82. Minimum reflux of stagrs can be achieved through a. total reflux c. alternate use of tray and packings b. maximum reboiling d. oversized condenser 83. The overall separation efficiency can be dictated by a. relative volatilies c. intimate contact on each tray/stage b. number of trays d. all of the above 84. As the temperature of the liquid increases, its vapor pressure tends to a. decrease c. remain the same b. increase d. fluctuate relative to the liquid's density 85. What is the boiling point of a benzene-toluene mixture under atmospheric pressure if the mixture contains 0.682 mole fraction toluene? a. 100degC c. 89degC 212 b. 95degC d. 98degC 86. In the above question, when the resulting vapor is condensed, the liquid composition contains how much benzene (mole fraction)? a. 0.532 c. 0.425 b. 0.83 d. 0.18 87. What are the advantages of extraction processes compared with other separation processes? a. Extraction is a separation process which involves no evaporation; carried out mostly at ambient temperature and can be used as a separation process for high temperature sensitive products. b. All streams are in liquid phase, therefore the system pressures are lower, resulting in thinner walls needed for the equipments. c. There are no specific advantages. d. The treatment of the process products is easier, since all are in liquid phase. There is no cooling energy needed. 88. 88.In liquid-liquid extraction 10 kg of a solution containing 2 kg of solute C and 8 kg of solvent A is brought into contact with 10 kg of solvent B. Solvents A and B are completely immiscible in each other whereas solute C is soluble in both the solvents. The extraction process attains equilibrium. The equilibrium relationship between the two phases is Y* = 0.9X where Y* is kg of C/kg of B and X is kg of C/kg of A. Choose the correct answer. a. the entire amount of C is transferred to solvent B b. less than 2 kg but more than 1 kg of C is transferred to solvent B c. less than 1 kg of C is transferred to B d. no amount of C is transferred to B 89. Determine the state of water according to the following condition of at 440ºF with density of 842.3679kg/m³. a. saturated liquid b. saturated vapor c. sub-saturated d. superheated 213 90. A utility runs a Rankine Cycle with a water boiler at 3.5MPa and the cycle has the highest and lowest temperature of 450ºC and 45ºC respectively. What is the cycle efficiency? a. 0.36 b. 0.84 c. 0.53 d. 0.61 214 ANSWER KEY MIDTERM EXAMINATION 1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. C. Sieve diameter A. Feret's diameter B. API D. Topaz A. 2.89 A. 21 C. 0.874 B. 38% C. 0.874 A. 0.806 A. 36 inches B. Cyclones A. 18 kwh/ton A. 8.88kW(kg/s) A. 3400 C. 11 C 2.2ºF B. 2.1ºF D. 8 B. 8500 cal/mol C. same B. 2 C. 60 C. The space velocity of 3 hr −1 means that the one third reactor volume of feed at specified conditions are being fed into the reactor. A. 0.15 B. 2/(kCA0) B. 0.75 A. 0.67 D. Classification B. Thickener B. The velocity of the surface A. I only D. In practical terms, the susceptibility of the engine materials to corrosion is not a key limitation on the operating efficiency. C. II and III B. Reversible A. I = - II + III + IV – V C. I and IV A. V2(I) = V2(II) A. I and II 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. A. 4,550min D. 008 A. 30 A. Is that corresponding to equilibrium with the incoming feed D. 540KJ/kg C. 128.4deg C B. 25 deg F D. 3 B. 5.27 C. The freezing point of the solution that remains a liquid is getting lower and lower as freezing proceeds D. The saturated vapor line B. 0.100 B. duhring's plot is used for calculating the concentration of solution B. Aluminum foil A. 1-1 heat exchanger A. reduce drying temperature D. diameter of randomly packed towers is normally more than 1.2m A. increase of reaction time B. Adsorption bar A. In a continuous flow reactor, uniform concentration can not be maintained throughout the vessel even in a well agitated system D. Mach number D. None of these B. Bypass E. 8.11 C. 54 C. 80 C. 4 E. 2.25 D. 5.39 B. Semi-anthracite C. CO A. 2.2 D. 11.55 C. 0.000931 A. Double-pipe HE C. Both a and c 215 40. A. 0.189m/s 41. 42. 43. 44. 45. C. Velocity of the flow C. Gustaf de Laval A. below 100,000kPa and below 600ºC A. higher compression ratio B. 73ºF 82. 83. 84. 85. 86. 87. A. Total reflux D. all of the above B. increase D. 98degC A. 0.532 A. Extraction is a separation process which involves no evaporation; carried out mostly at ambient temperature and can be used as a separation process for high temperature sensitive products. 88. B. less than 2 kg but more than 1 kg of C is transferred to solvent B 89. C. Sub-saturated 90. A. 0.36 MIDTERM EXAMINATION SOLUTIONS 5. 3inches = 0.7=0762m 170lb/ft3 = 2723.kg/m3 Area = (0.0762)2 = 0.0182m2 Volume = A = V (0.0762)3 = 2.3167 x 10−4 m3 6 100cm 0.0182m2 (1m)² = 0.2885 x 10 = . kg 1000g) 2.3167 x 10−4 m3 x2723 3 (1kg m 6. P Dpa = k log T Dpb 11kJ/kg = k log 1 0.3 k = 21.03738 P 1 = 21.03738 log T 0.01 216 P = . / T 7. and 9. Volume = r 2 h = ()(0.5)²(1) = 0.7854 m³ Radius of sphere = 4r³ = 0.7854 m³ 3 R = 0.5724 m Surface Area = 4r 2 = 4()(0.5724)² = 4.11 m² Surface Area of particle = 2(0.5)(1 + 0.5) = 4.71 m² f= 4.11 m² = . 4.71 m² 10. 1 3 6(Vp) f= Ap 2/3 1 3 6(6)2/3 = = . 6x6 14. P Dpa = k log T Dpb 13kJ/kg = k log 50 100 k = 18.599 P 75 = 18.599 log T 25 P = . ( ) T 15-16. Q = S () = mCpΔT 217 () @383.15K = 2690.27 − 461.31 = 2228.96 kJ/kg 2228.96kJ 3400kg 1hr 1000J W ( )( ) = 2840 2 0 (110 – 43)0 C (A) kg hr 3600s 1kJ m (C) A = . ² 19. ln Ca − ln Cao = kt ln 2 − ln 1 = k(4) k = 0.1733 ln Ca − ln 1 = 0.1733(12) Ca = . 20. 1 1 − = −kt Cao Ca 1 1 − = −k1(40) 0.1 0.1(0.8) k1 = 0.0625 1 1 − = −k2(35) 0.1 0.1(0.6) k2 = 0.1905 Ea = RT1T2 k1 ln T1 − T2 k2 Ea = (8.314)(298.15)(323.15) 0.0625 ln 298.15 − 323.15 0.1905 Ea = 35709.4747J/mol = . / 4.184J/cal 22. 218 k= Cbe m + Xa 0 + 2/3 = = = Cba 1 − Xae 1 − 2/3 23. I + A → 2B + C + I = 1 1 0 0 =2 = 1 0 2 1 =4 = 4−2 =1 2 V = Vo(1 + xa) V = (1 + xa) Vo 1.6 = (1 + 1xa) xa = 0.60 = % 25. CSTR Xa = 0.3 1 = 0.1 = 10 10 = Cao − Ca −Ra −Ra = 0.3 Cao 10 −Ra = 0.03Cao PFR Xa = ? 1 = 0.2 =5 219 Xa 5 = Cao ∫ 0 Xa 5 = Cao ∫ 0 Xa 5= ∫ 0 dXa −Ra dXa −0.03Cao dXa −0.03 1 (Xa − 0) 0.03 5= = . 26. CSTR A -> R -Ra = kCa² Xa = 0.50 k = Xa Cao (1 − Xa)² = 0.5Cao kCao² (1 − 0.50)² = 27. 1 = V1 V0 V2 =6 V1 1 =6 2 220 Xa 1 kCao (1 − Xa)² =6= 0.5 2 kCao(1 − .5)² Xa = . 28. kCao = 2= Xa 1 − Xa Xa 1 − Xa = . 40. Ut = Ut = 2 (9.81)(1000)²(7870 − 900) 18(50x10−3) 0.303m s 46. 200degC = 473.15 K 100 degC = 373.15 K 1 atm = 101325 Pa 20 degC = 293.15 K 100ft3/min = 0.047m3/s 0.81 cal/g degC = 3.389 J/g-K 1000 gallons = 3.785412m3 Density of oil = 880kg/m3 Cp of air = 1033 J/g-K (Thermodynamic Property of Air) = MwP 28.84(101325) = = 1.198kg/m3 RT 8.314(293.15)(1000) 221 m = 3.785412m3 (880kg) = 3331.16 kg m3 3.389J Q = mCpΔT = 3331.16 kg ((0.047 m3 s)(gK)(1000g kg)(473.15 − 373.15)K = 1.198kg m3)(t)(1033)(373.15 − 293.15)K t = 242617.47s = . 48. 1200mm = 3.936ft 75 mm = 0.246ft 76.65 N= √3.936 − 0.246 = 39.90 51. I²R 200²(0.1) = = 203718327.2 (r)²L (5)²(1) 1000x2 q= 5 203718327.2( )² q(r)² 1000x2 + 114 = . To = + Tw = 4k 4(22.5) 53. DOF F = C-P +2 F = 3 – 2 +2 F=3 71-72. 222 CH3OH + 0.5 O2 -> HCHO + H2O ->1 1 0.5 1 1 CH3OH -> HCHO + H2 ->2 1 1 1 Total methanol entering the reactor = Methanol reacted by oxidation + methanol reacted by decomposition + recycle methanol = 1 + 3 + 1 = 5 kmol/hr. Conversion per pass = 100 x (Total methanol reacted /Total methanol entering the reactor) = 100 x 4/5 = 80% Fresh methanol rate = Total methanol entering the reactor - recycle methanol = 5 - 1 = 4 kmol/hr. 73. 80% CH4 15% C2H6 5% C3H8 At C 0.80 0.30 0.15 1.25 At H 3.2 0.9 0.40 4.5 H2O = At H/2 = 4.5/ 2 = 2.25 77. mCpΔT (1) = mCpΔT (2) (0.5)(30 − 18)(4) = m(71 − 62)(1.2) 223 m = . / 78. ΔTlm = (62 − 18) − (71 − 30) 62 − 18 ln 71 − 30 ΔTlm = 42.48 degC Q = UAΔTlm (0.5)(30 − 18)(4)(1000) = (50)A(42.48) = . ² 78. Fouling resistance 28degC instead of 30degC ΔTlm = (62 − 18) − (71 − 28) 62 − 18 ln 71 − 28 ΔTlm = 43.498 degC Q = UAΔTlm (0.5)(30 − 18)(4)(1000) = (U)(11.55)(43.498) = . /² rf = rf = 1 Uactual − 1 Uclean 1 1 − 47.77 50 = 9.336 x − 90. 1: 45oC , x = 0 => h1 = 188.42 , v1 = 0.00101 , Psat = 9.6 kPa 224 3: 3.5 MPa , 450oC => h3 = 3337.2 , s3 = 7.0051 C.V. Pump Rev adiabatic -wP = h2 - h1 ; s2 = s1 since incompressible it is easier to find work as -wp = ∫ v dP = v1 (P2 - P1) = 0.00101 (3500 - 9.6) = 3.525 => h2 = h1 - wp = 188.42 + 3.525 = 191.95 C.V. Boiler : qh = h3 - h2 = 3337.2 - 191.95 = 3145.3 C.V. Turbine : wt = h3 - h4 ; s4 = s3 s4 = s3 = 7.0051 = 0.6386 + x4 (7.5261) => x4 = 0.8459 => h4 = 188.42 + 0.8459 (2394.77) = 2214.2 wt = 3337.2 - 2214.2 = 1123 kJ/kg C.V. Condenser : qL = h4 - h1 = 2214.2 - 188.42 = 2025.78 kJ/kg ηcycle = wnet / qH = (wt + wp) / qH = (1123 - 3.5) / 3145.3 = 0.356 225 SEMI-FINAL EXAMINATION GENERAL ENGINEERING 1. To be able to pass the ChE Licensure Examination no grades should be lower than 50 for all three examinations and the average should be 70 or higher. A student, after taking the 1st day (30% weight) and 2nd day (40%) estimated her grades to be 62 and 55 respectively. What grade should she aim on the 3 rd day (30%) to be a chemical engineer? A. 98 B. 89 C. 95 D. 83 2. ∫ x2 3 ex 1 dx = 3 A. − 3 lne x + C 3 B. − C. − ex +C 3 1 3 3e x 1 3 D. 3 lne x + C E. − x3 3 3x +C +C 3. If y=tan u, u=1/v, and v=ln x, what is the value of dy/dx at x=e? A. 0 C. 1 E. sec2e B. 1/e D. 2/e 4. ∫ sin(2x + 3) dx = A. ½ cos(2x+3) + C B. cos(2x+3) + C C. –cos(2x+3) + C D. -½ cos(2x+3) + C E. -1/5 cos(2x+3) + C 5. What type of polyhedron has pentagon as its face? A. dodecahedron C. octahedron B. hexahedron D. tetrahedron 6. The altitude of the sides of a triangle intersect at the point known as A. incenter B. centroid C. circumcenter D. orthocenter 7. A man left his home at past 3 o'clock PM as indicated in his wall clock, between 2-3 hours after, he returns home and noticed that hands of the clock interchanged. At what time did the man leave his home? A. 3:31.47 B. 3:21.45 C. 3:46.10 D. 3:36.50 8. Locate the centroid of the plane area bounded by y=x 2 and y=x. A. 0.4 from the x-axis and 0.5 from the y-axis B. 0.5 from the x-axis and 0.4 from the y-axis C. 0.4 from the x-axis and 0.4 from the y-axis D. 0.5 from the x-axis and 0.5 from the y-axis 9. From the time 6:15 PM to the time 7:45 PM of the same day, the minute hand of a standard clock describe an arc of? 226 A. 60O B. 90O C. 180O D. 540O 10. What is the coefficient of x5 in the polynomial expansion of (2-x+x2)4? A. -128 B. 128 C. 125 D. 250 11. One of the satellites of Jupiter has an apogee of 40000 km and a perigee of 6600 km assuming the radius of Jupiter as 6400 km, what will be the eccentricity of the elliptical path described by the satellite with the center of Jupiter at one of the foci? A. 0.56 B. 0.20 C. 0.78 D. 0.33 12. If equal spheres are piled in the form of a complete pyramid with an equilateral triangle as base, find the total number of spheres in the pile if each side of the base contains 4 spheres. A. 15 B. 18 C. 20 D. 21 13. What is the fraction in lowest term equivalent to 0.133133133? A. 133/666 B. 133/177 C. 133/888 D. 133/999 14. In how many different orders can 7 books be arranged on a shelf if this 3-volume work is not merely not to be separated but must be kept in the proper order? A. 120 B. 720 C. 5040 D. 4050 15. Find the equation of the conic with eccentricity 2 and foci at (6, 0) and (-6, 0). A. 9x2-27y2=243 C. 27x2-9y2=243 B. 8x2-25y2=200 D. 25x2-8y2=20 16. Find a point in the parabola y2=4x at which the rates of change of line ordinate and abscissa are equal. A. (4, 4) B. (3, 2) C. (1, 2) D. (0, 0) 17. Find the value of A: (x2+2x2+10)/(x3+2x2+5x) = A/x + B(2x+2)/x2+2x+5 + C/x2+2x+5. A. -2 B. 0.5 C. -0.5 D. 2 18. An enterprising engineer purchased a fleet of trucks for Php 780,000.00 payments were made by an immediate cash payment of Php 50,000.00 and twelve month – end payments of Php 64,860.00 each. Another deal referred to finance the purchase at an interest rate of ¾% per month on the unpaid balance. Which offer should the engineer have accepted? A. The first offer C. Either of the two offers B. The second offer D. Neither of the two offers 19. If conversed sinθ=0.134, find the value of θ. A. 30O B. 45O C. 60O D. 90O 227 20. At what time after 12:00 noon will the hour hand and the minute hand of the clock first form an angle of 120O? A. 12:18.818 B. 12:21.818 C. 12:22.818 D. 12:24.818 For items 21-24, 21. In the figure, the radius of the circle is 1, what is the perimeter of the shaded part of the figure? A. π B. 4π/3 C. 2π/3 D. π/3 22. A 200 mm pulley, loaded as shown, is keyed to a shaft of 60 mm diameter. Determine the width "b" of the 70 mm long key if they allowable shearing stress is 60 MPa. A. 14.56 mm B. 15.84 mm C. 16.25 mm D. 17.46 mm 23. A 7/8 inch diameter bolt having a diameter at the root of the threads of 0.731 inch is used to fasten two timbers together as shown. The nut is tightened to cause a tensile strength of 18,000 psi in the bolt. Determine the outside diameter of the washers if their inside diameter is 9/8 inches and the bearing stress is limited to 800 psi. A. 3.18 in B. 3.65 in C. 4.1 in D. 4.3 in 24. Determine the position of maximum moment in the beam ABC. A. at A B. at B C. at C D. left of C 25. In a pile of logs, each layer contains one more log than the other layer above and the top contains just one log. If there are 105 logs in the pile, how many layers are there? A. 11 B. 12 C. 13 D. 14 26. What work is required to lift a 215 kg mass a distance of 5.65 m using a machine that is 72.5% efficient? A. 1.46x10-4 J B. 1.64x104 J C. 1.19x104 J D. 1.46x106 J 27. Two forces PQ and PR of magnitudes 5.0 kg and 8.0 kg, respectively, acts at a point P. The direction of PQ is N20OE, and the direction of PR is N65OE. Approximate the magnitude and direction of the resultant PS. A. 11.2 kg, N42OE B. 12.1 kg, N48OE C. 14.1 kg, N73OE D. 15.1 kg, N27OE 28. An electric motor drives a load, taking 18.8 amperes from 230-V source. How much is the power input of the motor? A. 2.343 kW B. 3.423 kW C. 4. 323 kW D. 3.343 kW 228 29. A rubber ball is made to fall from a height of 50 feet and is observed to rebound 2/3 of the distance it falls. How far will the ball travel before coming to rest if the ball continues to fall in this manner? A. 200 feet B. 225 feet C. 250 feet D. 275 feet 30. A resistor is connected across a voltage E1, dissipating a power P. If R was decreased to half, how much must E change to dissipate the same power? A. E must decrease to 0.707E1 B. E must decrease to 0.393E1 C. E must increase to 0.707E1 D. E must increase to 0.393E1 31. Which of the following numbers is a perfect number? A. 496 C. both A and B B. 8128 D. none of the choices 32. The equation 25x2+16y2-150x+128y+81=0 has its center at ______. A. (-3, -4) B. (3, -4) C. (-3, 4) D. (3, 4) 33. The number 0.123123123123..... is A. rational B. surd C. irrational D. transcendental 34. Arjie, aside from being a terrorist, is a boatman who used to row the Tingloy marsh, 4.8 miles, with the stream and back in 14 hours, but finds that he can row 14 miles with the stream in the same time as 3 miles against the stream. Find the rate of the stream in mph. A. 1.5 B. 1 C. 0.8 D. 0.6 35. Let A be a 50x50 matrix and B a 50x20 matrix. Which of the following expression will have no definite answer? A. BBT (product of B and B transpose) B. BTB (product of B transpose and B) C. ABT (product of A and B transpose) D. BTA (product of B transpose and A) 36. Find the polar equation of the circle of radius 3 units and center at (3, 0). A. r=3cosθ B. r=3sinθ C. r=6cosθ D. r=9sinθ 37. Angles are measured from the positive horizontal axis, and the positive direction is counterclockwise. What are the values of sin B and cos B in the 4 th Quadrant? A. Sin B>0 and Cos B0 B. none of these D. Sin B waves 73 s before the arrival of the longitudinal waves. How far away was the earthquake? A. 780,000 m B. 110,780 m C. 870,000 m D. 710,800 m 39. The general equation of a conic section is given by the following equation; Ax2+Bxy+Cy2+Dx+Ey+F=0. A curve may be identified by which of the following conditions? A. B2-4AC0 D. B2-4AC 230 47. If the average of the seven numbers is 88, then the first number is increased by 12, second number is increased by 20, the third by 10, the fourth by 15, the fifth by 13, the sixth by 12 and the seventh by 16. What will be the new average of the seven numbers? A. 102 B. 89 C. 201 D. 112 48. The total surface of two cubes is 150 sq. m. The total length of their edges is 84 cm. Find the edge of the larger cube. A. 4 B. 5.5 C. 6.4 D. 7.2 49. How many squares can be formed in a chessboard? A. 112 B. 305 C. 204 D. 256 50. As shown in the figure, the side of the square ABCD has a length of 2 cm. A smaller square is formed by joining the midpoints of each side. Then smaller square is formed using same method but from the previous square formed and the process repeated indefinitely. What is the total area of all the squares formed using this process? A. 4 cm2 C. 12 cm2 B. 8 cm2 D. 16 cm2 51. A tank has 3 inlet pipes, A, B, and C. When all 3 pipes are fully open, the tank is filled in 3 hours. If only A and B are open, it takes 4 hours to fill the tank. If only A and C are open, it takes 8 hours to fill the tank. How long would it take pipe A, running alone, to fill the tank? A. 12 B. 24 C. 16 D. 32 52. The cost C of a product is a function of the quantity x of the product: C(x)=x 24000x+50. Find the quantity for which the cost is minimum. A. 1000 B. 1500 C. 2000 D. 3000 53. The integral of a function between certain limits divided by the difference in abscissas between those limits gives the _____ of the function. A. constant B. derivative C. average D. domain 54. Find the integrating factor for the equation (x2+y2-x)dx – ydy = 0 A. 1/(x+y) C. 1/(x2+y2) E. 1/y2 2 B. y/(x+y) D. 1/x 55. The equation of a circle on the y-axis and passes through the origin and the point (4, 2) is A. x2+y2-10y=0 C. x2+y2-10x=0 2 2 B. x +y -10x+10y=0 D. x2+y2+10y=0 231 56. Twelve persons are to sit at a round table. Two particular people insist on sitting opposite each other. Find the number of ways the twelve can be seated. A. 2638800 B. 6238800 C. 3826800 D. 3628800 57. A square and a regular hexagon have the same perimeter. If the area of the square is 2.25, what is the area of the hexagon? A. 2.250 B. 2.598 C. 2.838 D. 3.464 58. If money is worth 8% compounded quarterly, find the present value of a sequence of payments of $200 each at the end of each 3 months forever. A. $8620 B. $10,000 C. $10,200 D. 20,000 59. Determine the present value of a sequence of payments of $200 each at the beginning of each 3 months forever. A. $8620 B. $10,000 C. $10,200 D. 20,000 60. Determine the present value of a sequence of payments of $200 each at the end of each 3 months for 25 years. A. $8620 B. $10,000 C. $10,200 D. 20,000 61. The area of the region bounded by the curve y = e 2x , the x-axis, the y-axis, and the line x=2 is equal to A. B. e4 2 e4 2 e4 −e 1 C. 2 − 2 D. 2e 4 − e E. 2e 4 − 2 −1 62. If sin x = ey, 0 glucose + fructose glucose c. maltose + water —> glucose + b. lactose + water —> glucose + glucose glucose d. lactose + water —> galactose + 9. Which vitamin is not a fat soluble? a. A b. C c. K d. E 10. Which of the following potential contaminant is the most resistant to heat sterilization? a. Pseudomonas aeruginosa c. Aspergillus niger b. Clostridium botulinum d. Saccharomyces cerevisiae 11. Melamine is officially 1,3,5-triazine-2,4,6-triamine in the IUPAC nomenclature system. It is used in fire retardants in polymer resins because its high nitrogen content released as flame stifling nitrogen gas when the compound is burned or charred. What is the chemical formula of melamine? a. C3H6N3 b. C3H6N4 c. C3H6N5 d. C3H6N6 12. A sample of polystyrene prepared by heating styrene with tribromobenzoyl peroxide in the absence of air has the formula Br3C6H3(C8H8)n where n varies with the preparation. If a certain sample of polystyrene is found to contain 20.01 /o Br, what is the value of n? a. 8 b. 10 c. 20 d. 15 13. For the reaction 3A(g) + 3B (g) —> 2C (s) + 3D (g), the equilibrium concentration are 0.3M of A, 0.5 M B, 0.2 M of C and 0.5 M of D, find the equilibrium constants a. 37.04 b.0.74 c. 12.3 d. 0.075 14. A mixture of N2 and H2 was allowed to come to an equilibrium at a given temperature. An analysis of the mixture at equilibrium contained 2.0 mol N2, 3.0 mol H2, and 2.5 mol NH3. How many moles of H2 present at the beginning of the reaction? a. 3.5 b. 5.3 c. 7.5 d. 6.7 15. If an enzyme is inhibited non-competitively by the product a reaction sequence in which the enzyme precipitates, the enzyme is? a. Inhibited b. Modulator c. Allosteric d. Zymogen 16. A solution of 1.25 g of non-electrolyte solute in 20 g water freezes at 291.94K, find the molecular weight of the solute. 318 a. 110 b. 6.86 c. 180 d. 56.2 17. What is the pH of the resulting solution made by mixing 5ml of 0.2178M HCI and 15ml of 0.1156M NH3? Kwm =1 8x10 s a. 9.49 b. 9.90 c. 9.02 d. 12.74 18. Calculate the molarity of NaOH solution if 18.25mL was used to titrate 0.4815 gram of primary standard KHP a. 0.18 b. 0.13 c. 0.26 d. 0.16 19. What is the pH of a 0.068 M aqueous solution of sodium cyanide? Ka for HCN = 4.9 x 10'° a. 0.74 b. 2.93 c. 11.07 d.13.26 20. Histamine, an organic nitrogenous compound which can cause allergic rhinitis, can be produced in our body through the decarboxylation of the amino acid histidine. Given that 18 mM of the decarboxylase is used and 5 mM of histidine forms. Calculate the MichaelisMenten constant if the reaction velocity and the TON are 6 mM/s and 37/s respectively. a. 0.330 M b. 0.440 M c. 0.550 M d. 0.660 M 21. What weight of impure ferrous ammonium sulfate should be taken for analysis so that the number of centigrams of BaS04 obtained will represent five times the percentage of S in the sample? a. 0.59 g b. 0.69 g c.0.79 g d.0.89 g 22. An oxide of the element M has the formula M207 and it is known from experiments that 1.000 gram of M combines with an excess of oxygen to form 2.019 grams of oxide. The element M is a. aluminum b. chlorine c. manganese d. iron 23. All of the following are correctly stated underlying principles used to build up the configuration of a many electron atom, EXCEPT a. Pauli principle: no two electrons can have an identical set of quantum numbers. b. Aufbau principle: atomic orbitals are filled with electrons from lowest energy to higher energies. c. Hund's rule: electrons in degenerate orbitals are arranged to minimize the number of unpaired spins. d. All of the above statements are correct. 24. In the most stable conformation of trans-1,4-dimethylcyclohexane, what positions do the methyl groups occupy? 319 a. Axial, axial equitorial b. Equitorial, axial c. Equitorial, equitorial d. Axial, 25. The pKa for formic acid is 3.74. What is the pH of the solution resulting from addition of 0.50 moles of formic acid (HCOOH) and 0 30 mole sodium formate (HCOO-) to enough water to create a final volume of 1.0 L? a. 2.18 b. 2.78 c. 3.52 d. 4.28 26. Formic acid is a monobasic acid that is 4.6% ionized in 0.10M aq. solution at 25°C. If a 25 mL pipetful of a 0.25N aq. solution of formic acid is diluted to 200 mL and titrated with 0.33N NaOH, what indicator would be suitable in this titration? I a. Methyl orange c. Bromothymol blue b. Cresol red d. Phenolphthalein 27. A certain solution may contain any of the following solutes: NaH2P04, HCI, H3P04, Na2HP04. A 25 mL portion is titrated with 0.2N NaOH and with an indicator changing color at approximately pH 9, the end point is at 48.0 mL of NaOH. A second 25 mL sample is titrated with 0.2N NaOH, and with an indicator changing color at approximately pH 4, the end point is at 32.5 mL of the NaOH. What active solutes are present in significant amounts in the original solution? a. NaH2P04, HCl Na2HP04 b. HCl, H3P04 c. H3P04, Na2HP04 d. NaH2P04, 28. What should be the "iron value" of a solution of KMn04 so that when a sample of impure Na3As03 weighing 0.5 g is titrated to arsenate with the permanganate, the percentage of As203 in the sample will be twice the buret reading? a. 0.0113 g b. 0.0224 g c. 0.0335 g d. 0.0446 g 29. Bromide can be determined by precipitating as AgBr, heating in a current of Cl2 and weighing the resulting AgCl. What would be the gravimetric factor for finding the percentage bromine? a. Less than 1 b. 1 c. More than 1 d. Insufficient Information 30. Trouton's rule slates that many substances have entropies of vaporization close to 88 J/mol-K. Which of the following is the best rationale for Trouton's rule? a. Most substances have similar enthalpies of vaporization b. Most substances have similar boiling points. c. The change in disorder in going from one mole of liquid to one mole of gas is similar for many substances. d. Entropy changes for most processes are about 88 J/mol-K. 320 SOLUTIONS 1. Archaeologists can determine the age of an artifact made of wood or bone by measuring the amount of the radioactive isotope 14C present in the object. The amount of isotope decreases in a first order process. If 15.5% of the original amount of 14C is present in a wooden tool at the time of analysis, what is the age of the tool? The half life of 14C is 5730 years. a. 15,411.76 years b. 14,411.46 years c. 11,411.16 years d. 17,411.46 years Solutions: 1 ln ( ) = −kt 2 1 ln ( ) = −k (5730) 2 k = 1.20968 x 10−4 ln(0.155) = −1.20968x10−4 (t) = , . 2. Consider the molecular substances I2, H2O, and C8H18. Which of them is/are soluble in CCl4? a. only I2 C8H18 b. only H20 c. only C8H18 d. I2 and C8H18 e. H2O and 3.Consider the following half-reactions and select the strongest oxidizing agent present: Sr2+(aq) + 2e- —> Sr(s) E° = -2.89 V Cr2+(aq) + 2e- -> Cr(s) E° = -0.913 V Co2+(aq) + 2e- -> Co(s) E° = -0.28 V a. Cr2+(aq) Co(s) c. Co2+(aq) b. Sr2+(aq) d. Sr(s) e. 4. A solution composed 10 grams of non-volatile organic solute in 100 grams of diethyl ether (CH3CH2OCH2CH3) has a vapour pressure of 426.0 mm Hg at 20°C. If the vapor pressure of the pure diethyl ether is 442.2 mm Hg at the same temperature, what is the molecular weight of solute? a. 149.6g/mole b. 164.8 g/mol c. 186.4 g/mol d. 194.8 g/mol Solutions: 321 (10 100 100) (426) = ( ) (442.2) + x 74.14 74.14 = . / 5. The chemical name of Turnbull's blue is a. ferrous ferricyanide chloride b. cuprous chloride c. ferric ferrocyanide d.cupric 6. Find the pH of a solution made by diluting one drop (0.04 mL) of 0.10 N HCI to 10 liters. A. 6.37 B. 7.24 C. 8.14 D. 8.55 Solutions: pH = −log[H +] mol 0.1 L (0.4x10−3 L) pH = − log(10 L = . 7. An air sampling program sampled 100,000 L of particle size. The following mass of particles were collected: 12 mg retained with size greater than 2.5 µm; and 6 mg retained with size less than 2.5 µm. What are the PM2.5 and TSP concentrations (in ppm) of this air sample respectively? a. 6.0 x 10-4; 1.8 x 10-4 c. 6.0 x 104; 6.0 x 10-5 b. 1.2 x 10-4; 1.8 x 10-4 d. 1.2 x 10-4; 6.0 x 10-5 Solutions: 12 mg = . − 100000 L 18 mg = . − 100000 L 8. Disaccharides are carbohydrates composed of two monosaccharide residues united by a gycolylycosidic linkage. Which of the following is inappropriate? a. sucrose + water —> glucose + fructose glucose c. maltose + water —> glucose + b. lactose + water —> glucose + glucose glucose d. lactose + water —> galactose + 322 9. Which vitamin is not a fat soluble? a. A b. C c. K d. E 10. Which of the following potential contaminant is the most resistant to heat sterilization? a. Pseudomonas aeruginosa c. Aspergillus niger b. Clostridium botulinum d. Saccharomyces cerevisiae 11. Melamine is officially 1,3,5-triazine-2,4,6-triamine in the IUPAC nomenclature system. 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KNH3 =1 8x10-5 a. 9.49 b. 9.90 c. 9.02 d. 12.74 Solutions: NH3 + HCl → NH4 + + Cl − 1.734 i i 0.645 1.089 0 0 1.089 00 -1.089 cc -1.089 -x 1.089 x x 1.089 1.089+x x 0.645 ee0.645-x 324 0 NH3 + H2 O → NH4 + + OH − 1.8 x 10−5 = (1.089 + x)(x) (0.645 − x) x = 1.0661x10−5 M [OH −] pH = 14 − pOH pH = 14 + log(1.0661x10−5) = . 18. Calculate the molarity of NaOH solution if 18.25mL was used to titrate 0.4815 gram of primary standard KHP a. 0.18 b. 0.13 c. 0.26 d. 0.16 Solutions: 0.4815 g KHP ([NaOH] = 1 mol KHP 1 mol NaOH)( ) 204.05 g 1 mol KHP 0.01825 L [NaOH] = 0.1293 M = . 19. What is the pH of a 0.068 M aqueous solution of sodium cyanide? Ka for HCN = 4.9 x 10-10 a. 0.74 b. 2.93 c. 11.07 d.13.26 Solutions: [M] 1 pH = 14 + log ( ) 2 Ka 1 0.068) pH = 14 + log (2 4.9 x 10−10 = . 20. Histamine, an organic nitrogenous compound which can cause allergic rhinitis, can be produced in our body through the decarboxylation of the amino acid histidine. Given that 18 mM of the decarboxylase is used and 5 mM of histidine forms. Calculate the MichaelisMenten constant if the reaction velocity and the TON are 6 mM/s and 37/s respectively. a. 0.330 M b. 0.440 M c. 0.550 M d. 0.660 M Solutions: V = Vmax (Cs) Km + Cs 325 37 (s)(5mM)(18mM) mM 6 = s Km + 18mM Km = 550 mM = . 21. What weight of impure ferrous ammonium sulfate should be taken for analysis so that the number of centigrams of BaS04 obtained will represent five times the percentage of S in the sample? a. 0.59 g b. 0.69 g c.0.79 g d.0.89 g 22. An oxide of the element M has the formula M207 and it is known from experiments that 1.000 gram of M combines with an excess of oxygen to form 2.019 grams of oxide. The element M is a. aluminum b. chlorine c. manganese d. iron Solutions: 1 g M + O2 = 2.019 g M2 O7 2M+ 1gM(7 O → M2 O7 2 2 1 mol M 1 mol M2 O7 2x + 7(16))( )(= 2.019 g M2 O7 xgM 2 mol M 1 mol M2 O7 x = 54.9558 g mol , 23. 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with 0.33N NaOH, what indicator would be suitable in this titration? a. Methyl orange c. Bromothymol blue b. Cresol red d. Phenolphthalein 27. A certain solution may contain any of the following solutes: NaH2P04, HCl, H3P04, Na2HP04. A 25 mL portion is titrated with 0.2N NaOH and with an indicator changing color at approximately pH 9, the end point is at 48.0 mL of NaOH. A second 25 mL sample is titrated with 0.2N NaOH, and with an indicator changing color at approximately pH 4, the end point is at 32.5 mL of the NaOH. What active solutes are present in significant amounts in the original solution? a. NaH2P04, HCl Na2HP04 b. HCl, H3P04 c. H3P04, Na2HP04 d. NaH2P04, 28. What should be the “iron value" of a solution of KMn04 so that when a sample of impure Na3As03 weighing 0.5 g is titrated to arsenate with the permanganate, the percentage of As203 in the sample will be twice the buret reading? a. 0.0113 g b. 0.0224 g c. 0.0335 g d. 0.0446 g 29. 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Determine the volume Change in m3 when 1 kg of saturated water is completely vaporized at a pressure of 1 kPa. a. 115.1 b. 120.8 c. 129.2 d. 134.0 4. Pick out the material having maximum Rittinger's number. (hint:make use of Che handbook by Perry) a. calcite b. quartz c. pyrite d. galena 5. Sphericity for cubical particle when its equivalent diameter is taken as the height of the tube is a. 0.5 b. √2 c. 1 d. √3 6. Friction bsses through valves and fittings are expressed in a. Velocity heads 328 b. roughness factor c. pressure drop d. Total Head With the following characteristics: length L = 30.48 m; inside diameter d = 0.0526 m; pipe roughness e = 0.000045 m; frictional pressure drop delta P = 15720 N/m 2; liquid dynamic viscosity p = 0.01 Pa-s; liquid density p = 1200 kg/m3. Calculate: 7.the Reynolds' number. a. 7138 b. 15000 c. 8273 d. 9569 8. The faning friction factor f. a. 0.00884 b. 0.00727 c. 0.00990 d. 0.00698s 9. 1000 cfm of air at 95degF dry bulb and 70degF wet bulb is mixed with 2000 cfm of air at 65degF dry bulb and 50degF wet bulb. What is the dry bulb temperature of the mixed stream? a. 80degF b. 78egF c. 75degF d. 63degF 10. A first order reaction with respect to A takes place in a PFR. If equal moles of B and C are mixed with A and allowed to react for 1.5hr after which time half of A had been consumed. How much of A is left unreacted after 3 hrs. ? a.18% b.13% c. 35% d. 25% 11. 1 lbm of nitrogen is compressed at a constant temperature of 700Ffrom 10 ft3 to 5 ft3. If the process is non-flow and if no work is done on the gas except by a moving piston, how much heat is added to or removed from the gas during the process? a. +30.27 BTU b. - 30.27 BTU c. +28.54 BTU d. -26.07 BTU 12. Solubility of a substance which dissolves with an increase in volume and liberation of heat will be favoured by a. low pressure and high temperature. b. low pressure and low temperature. c. high pressure and low temperature. d. high pressure and high temperature. For 13-14.The analysis of a flue gas from a fuel gas containing no nitrogen is 4.62% C02, 3.08%CO, 8.91%02, am} 83.39% N2. 329 13. moles of water (H20) formed a. 7.04 moles b. 14.08 moles moles c. 15.07 moles d. 22.11 14. moles of air supplied per 100 moles of dry flue gas a. 1.055 b. 1.087 c. 1.124 d. 1.148 15. With the same reaction time , initial concentration and feed rate , the reaction 2A -5 B is carried out separately in CSTR an P.F. reactor of equal volumes. The conversion will be a. Higher P.F > reactor b. Same in both the reactors c. Higher in CSTR d. data insufficient, can’t be predicted 16. A first order reaction requires two unequal sized CSTR. Which of the following gives a higher yield? a. Large reactor followed by smaller one b. Smaller reactor followed by larger one c. either of the arrangement (a) or (b) will give the same yield d. data insufficient, can’t be predicted 17. A control structure with two feedback controllers with the output of the primary controller changing the set point of the secondary controller whose output goes to the final controller. a. Feedback control b. Ratio control c. Cascade control d. Override control 18. The degrees of freedom associated with ternary distillation process according to the Gibb's phase rule is a. 2 b. 3 c. 4 d. 5 19. If % moisture content of a solid on dry basis is X, then % moisture content on wet basis is 330 a. 100X/(X+100) b. X/(1+X) c. (100+X)/X d. 100(1-X)/X 20. The major problem in leaching is to promote diffusion of the solute out of the solid and the liquid, The most effective way of doing this is. a. to reduce the solid to the smallest size feasible b. to use crossflow evaporation c. to use counter current operation d. to use parallel operation 21. Desirable value of absorption factor in an absorber is. a. 1 b. 1 d. 0.5 22. Which has the lowest water content? a. dew point at 20degC b. 70%RH d.60%saturation c. absolute humidity of 0.05 23. Which of the following uses air as a typical working fluid? a. Carnoot Cycle b. Rankine cycle c. Reheat cycle cycle d. Brayton 24. A cylinder is fitted with a weightless, frictionless piston contains m pounds of air at TI , VI and ambient pressure Pa. Heat is ten added until the air in the cylinder s at T2, V2 and Pa. What is the expression for the heat transferred during the process? a. mCv(T2-T1) b. mCv(T2-T1)-Pa(V2-V1) c. mCv(T2-T1)+Pa(V2-V1) d. mCp(T2-T1)+Pa(V2-V1) 25. A tank holds nitrogen gas at 82 degree Celsius and 940 mmHg. After releasing 2 grams of the remaining inside the talk then exerts a pressure of 480 mmHg at 30 degree Celsius. How much nitrogen gas was originally in the tank? a. 3.0 g b. 5.0 g c. 139.4g d. 154.39 26. A camot engine, operating between 70F and 2000F is modified by raising the high temperature to 2150F and low temperature by 100F. Which of the following statements is incorrect? a. More heat is absorbed during vaporization b. More work is done during the reversible adiabatic expansion 331 c. Net work is increased d. Thermodynamics efficiency is increased 27. Gaseous propane at 770F is mixed with air at 260F and burned. If 300% theoretical air is used, what is the adiabatic flame temperature? a. 1766degF b. 166degF c. 766degF d. 1616degF 28. Water flowing at 1.2gal/min at 50F is to be heated to 1500F with saturated stream at 14.7 psia. Calculate the steam flow rate required in lb/min to heat the water in a "parallel type" heat exchanger. a. 3.01 lb/min 4.01lb/sec b. 4.03 lb/min c. 1.03 lb/min d. 29. Steam is delivered by a boiler at 550 psia and 7000F. After expansion to 110 psia the steam is reheated to 700F. Expansion occurs to 1.5 inHg(abs). For ideal reheat cycle, calculate on the basis of 1 lb of steam the thermodynamic efficiency. a. 27.6% b. 37.6% c. 17.4% d. 0.37% 30. A helical coil made of 3" OD x 16 gauge type 316 stainless steel tubing has a total of 15 turns on a 72" pitch diameter. If the water at 80 0F flows through the coil at 150 gpm, calculate the pressure drop of the coil in psi. a. 11.7 psi b. 21.1 psi c. 14.7 psi d. 31.1 psi 31. A large centrifugal pump has a 10" diameter inlet and 5" diameter outlet. The measured flow rate is 818 gpm. The measured inlet pressure is 5"Hg above atmospheric and the discharge pressure measured at 4 ft above the pump outlet is 30.7 psia. Pump input is 10 hp. Find the pump efficiency. 32. The parallel wooden outer and inner walls of a building are 15 ft long, 10 ft high and 4 inches apart, The outer surface of the inner wall is 700F and the inner surface of the outer wall is 0F. Calculate the heat loss in BTU/hr neglecting any leakage of air through the walls. 33. Suppose the air space is divided in half by a 0.01 inch aluminium foil. How much would this affect the heat transfer through the air space? 34, A large sheet of glass 2 inches thick and initially 300F throughout is plunged into a stream of water having a temperature Of 60F How long will it take to cool the glass to a 332 temperature of 100F in the centre of the slab? For glass, k = 0.4 BTU/ht-ft-F, density = 1lb/ft3 and cp=0.2 BTU/lbdegF. 35. If a counter current concentric pipe heat exchanger is heating air from 80 to 100F using condensing steam at 220F, estimate how many times as much as air could be heated within the same range by steam condensing at 250F. ANSWER KEY Removal Examination-Part II 1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. A. 1 A. 1.02 C. 129.2 D. Galena C. 1 A. Velocity Heads A. 7138 A. 0.00884 C. 75 degF D. 25% D. -26.07 BTU B. Low pressure and low temperature B. 14.08 moles A. 1.055 C. Higher in CSTR C. Either of the arrangement (a) or (b) will give the same yield C. Cascade Control B. 3 A.100X/(X+100) A. to reduce the solid to the smallest size feasible A.1 A. dew point at 20degC D. Brayton cycle C. mCv(T2-T1)+Pa(V2-V1) B. 5.0 g D. Thermodynamic Efficiency A. 1766degF C. 1.03 lb/min B. 37.6% A. 11.7 psi B. 78% 418 BTU/hr qAl=0.165 q 0.45 hrs. 5.7 times 333 SOLUTIONS 2. P=gh =13600 kg/m3 g= 9.7537 m/s2 P= 13600 kg/m3 x 9.7537 m s2 x 0.78359 m=1039439642 Pa P= 1.0258 atm 3. ΔV=Vg-Vs = 129.1833-0.001= 129.2 m3/kg 5. $\varnothing cube$ = (7. Nre = Nre = 6 Vp 6 √23) ( ) =( ) (2)=1 Dp Sp √2 6√2 Dv 1.13m)(1200kg/m3) s (0.0526m)(0.01 Nre = 7132.56 $D\Delta P$ 8. f = 2V 2 L (0.0526m)(f= 2(1200kg) (1.13)2 (30.48m) m3 f = 0.008852 10. C = Coe −kt 0.5 = 1e −k(1.5) 334 15720N m2) k = 0.46209 C = 1e −0.46209(3) C=25% 11. Convert all to SI units 1lbm = 0.45392 kg = 453.92 g (453.592)(1 mol/28.02 grams N2) = 16.19 mol N2 10 ft3 = 0.283 m3 5ft3 = 0.142 m3 For isothermal Process Q = nRT(ln V2/V1) Q = (16.19)(8.3145)(ln 0.142/0.283) Q = -27307.9953 Joules = -25.882 BTU 13. O2 unaccounted for = O2 in air – (CO2 – CO/2 –O2) O2 in air = 83.39 (21/79) = 22.17 moles O2 in air O2 unaccounted for = 22.17 moles O2 in air – 4.62 moles CO2 – 3.08/2 moles CO – 8.91 moles O2) O2 unaccounted for = 7.1 moles Net H2 = 7.1 moles x 2 = 14.20 moles 14. moles of air supplied per 100 moles of dry flue gas = (O2 in air + N2 in air)/100 moles dry FG moles of air supplied per 100 moles of dry FG = (22. 17 mol O2 in air + 83.39 mol N2 in air)/100 335 moles of air supplied per 100 moles of dry FG = 1.0556 25. PV=nRT P nT P = nT 940 (82+273.15)(n) n= 0.1194 moles x 480 = 0.07142(30+273.15) 28 $grams$ 1 $mole$ =5.34 grams 27. C3H8 + a (TA)O2 + a(TA)(3.76)N2 bCO2 + dH2O + a(TA-1)O2 + a(3.76)(TA)N2 C: 3=b H: 8=2d=4 O: 2a=2b+d, a=5 C3H8 + 15O2 + 56.4N2 3CO2 + 4H2O +10O2+56.4N2 HR + Q = Hp; Q=0 HR = Hp to calculate adiabatic flame temperature: {hf,$C3H8$−3hf,$CO2$−4$H2O$} Tp=298+ 3Cp,$CO2$+4Cp,$H2O$+10Cp,$O2$+56.4Cp,$N2$ 393522J {291235J/$mole$−3(−)−4(−241827J/$mole$} $mole$ Tp=298+ 3(45)+4(35)+10(35)+56.4(35) Tp=1236.48013K=1765.9942°F 28. Q = Q $mcp\Delta T$ = mv 336 (4.54 kg/min)(4.184 J/kg.K)(55.56K) = m (2256.61356 J/kgK) m= 0.467684 kg/min m= 1.0311 lb/min mass= 3.34 + 2 =5.34 grams 31. P1= ((5+30)/30)(14.696)(144) = 2469psf P2= 30.7(144) = 4421psf Q= 1.823 ft3/s W= qP= (1.823)(62.43)=113.787 lb/s D1= 10/12 =0.833 ft A1= π/4(0.0833)^2 = 0.545ft^2 V1= q/A1=(1.823/0.545)=3.342ft/s D2= 5/12 = 0.417 ft A2= π/4(0.417)^2=0.136ft^2 V2 =q/A2=(1.823/0.136)=13.367 ft/s Ha= (P2-P1)+(Z2-Z1)g/gc+((V2^2-V1^2)/2gc) Ha= 37.87 ft.lbf WHPa= Haw/550 = ((37.87)(113.87)/550)=7.834 Hp BHPa=10Hp PUMP efficiency = WHPa/ BHPa= (7.834/10)=78.3% 32. Q=kA ΔT 1 ΔX 337 Q=(0.12)(10*50) (70−0) 12 4 Q= 420 BTU/hr $T-T\infty$ 34. $To-T\infty$ = e hA)t cpV −(Assumptions: *thermal conductivity is equal to heat transfer coefficient *Volume is equal to 1 hA T − $T\infty$ −( )t = e cpV To − $T\infty$ 0.4 x 2 300°F − 60°F = e (0.2 x 1)t 100°F − 60°F t=0.447939 hrs 35. m (air) = m1 x 0.24 x (100-80) = 10 x (2.1888) x (121.111-100) = m2 x 0.24 x (100-80) = 10 x (2.1888) x (104.44-100) m1 24.111 = =5.42 times m2 4.444 338 Removal Examination – Part III General Engineering 1. A wooden rectangular parallelepiped 4m x 3m x 2m in dimension weighs 5 kg. Find the volume of the rectangular parallelepiped in m3. A. 22m3 B. 23m3 C. 24m3 D. 25m3 2. Find the distance from the point (2,3) to the line 3x + 4y + 9 = 0. A. 5 B. 5.4 C. 5.8 D. 6.2 3. The hypotenuse of a right triangle is 34 cm. Find the length of the shortest leg if it is 14 cm shorter than the other leg. A. 15 cm B. 16 cm C. 17 cm D. 18 cm 5 4. If sec2x = 2, what is the numerical value of 1 – sin2x? A. 2.5 B. 0.6 C. 1.5 D. 0.4 5. A 100 kg salt solution originally 4% by weight. Salt in water is boiled to reduce water content until the concentration is 5% by weight salt. How much water is evaporated? A. 10 kg B. 15 kg C. 20 kg D. 25 kg 6. If a regular polygon has 65 diagonals, then it has how many sides? A. 11 B. 12 C. 13 D. 14 7. If y varies directly as x and is 10 when x = 5, find the value of y if x = 7. A. 14 B. 12 C. 15 D. 17 8. The sum of the two interior angles of the triangle is equal to the third angle and 2 the difference of the two angles is equal to 3 of the third angle. Find the third angle. A. 15o B. 75o C. 90o D. 120o 9. What is the length of the latus rectum of the curve x 2 = -12y? A. 12 B. -3 C. -12 x y 10. Which of the following is perpendicular to the line 3 + 4 = 1? A. x - 4y – 8 = 0 B. 4x – 3y – 6 = 0 C. 3x – 4y – 5 = 0 x2 D. 3 D.4x+3y-11=0 y2 11. Given an ellipse 36 + 32 = 1. Determine the distance between the foci. A. 2 B. 3 C. 4 D. 8 12. Find the equation of the axix of symmetry of the function y = 2x 2 – 7x + 5. A. 4x + 7 = 0 B. x – 2 = 0 C. 4x – 7 = 0 D. 7x + 4 = 0 13. Find the equation of the line tangent to the curve x2 + y2 = 41 through (5,4). 339 A. 5x + 4y = 41 B. 4x – 5y = 41 C. 4x + 5y = 41 D. 5x – 4y=41 14. In how many relative orders can we seat 7 people at a round table with a certain 3 people side by side. A. 144 B. 5040 C. 720 D. 1008 15. Find the sum of the first 10 terms of the geometric progression 2, 4, 8, 16,... A. 1023 B. 2046 C. 1596 D. 225 16. If AB = 15m, BC = 18m and AB = 24m find the point of intersection of the angular bisector from the vertex C. A. 11.3 B. 12.1 C. 13.4 D. 14.3 17. Simplify: cos4x – sin4x. A. 2 B. 1 C. 2sin2x + 1 D. 2cos2x – 1 18. A 200 gm apple is thrown from the edge of a tall building with an initial speed of 20m/s. What is the change in kinetic energy of the apple if it strikes the ground at 50m/s? A. 130 Joules B. 210 Joules C. 100 Joules D. 81 Joules 19. Find the length of the vector (2, 4, 4). A. 7.00 B. 8.75 C. 6.00 D. 5.18 20. The horsepower required to raise a 150 kg drum to a height of 20 m over a period of one minute is: A. 0.41 hp B. 0.81 hp C. 0.66 hp D. 1.12hp 21. An object falls from a height of 97.5 m and strikes the ground with a speed of 21.90 m/s. How much higher should the object be in order to strike the ground with a speed of 27.60 m/s? A. 57.36 m higher B. 53.36 m lower C. 75.36 m lower D.36.75m higher 22. In what distance can a 3000 lb automobile be stopped from a speed of 30mi/h (44ft/s) if the coefficient of friction between tire and roadway is 0.70? A. 24.15 ft B. 59.25 ft C. 22.59 ft D. 42.95 ft dy 23. Solve: y = 3x2 dx A. y2 = x3 + c B. y2 = 2x3 + c C. y3 = 2x2 + c 24. Solve the exact equation: 2xy3dx + (1+3x2y2)dy = 0 A. x2y3 + x = c B. x2y3 + y = cx C. x2y3 + y = c D. y2 = 2x2+c D. x3y2 + x=cy 25. If a company spends P12,000 now and P5,000 per year for 10 years, with first P5,000 expenditure made 4 years from now, the rate of return would it make if its income were P4,000 per year starting in year 8 and continuing through year 25 is 340 A. 5.1% B. 1.5% C. 4.2% D. 1.2% 26. The present worth of a series that decreases uniformly, y P200 per year, from P4,000 in year 11 to P2,200 in year 20, if interest equals 105 is A. P7,709.1 B. P9,707.2 C. P10,709.1 D. 6,910 27. Material A is a water and Material B is a glass with an index of refraction of 1.52. If the incident ray makes an angle of 60o with the normal, find the direction of the reflected ray. A. 34.7o B. 49.3o C. 60.0o D. 91.3o 28. Determine the elongation in a helical steel spring composed of 20 turns of 20 mm diameter wire on a mean radius of 90 mm when the spring is supporting a load of 2.5kN. Use G = 83 GPa. A. 160 mm B. 165 mm C. 170 mm D. 175 mm 29. A telecommunication company purchased an equipment for P53 000 and paid P1 500 for freight and delivery charges to the job site. The equipment has a normal life of 10 years with a trade-in value of P5 000 against the purchase of a new equipment at the end of the life. Determine the annual depreciation cost. Interest at 6.5% compounded annually. A. P2 543 B. P3 668 C. P4 215 D. P5 956 30. “The condition of equilibrium or motion of a rigid body remains unchanged if a force of acting at a given point of the rigid body is replaced by a force of same magnitude and direction, but acting at a different point provided that the two forces have the same line of action.” This statement is known as A.Principle of Transmissibility C. Pappus Propositions B. Parallelogram Law D. Varignon’s Theorem 341 ANSWER KEY Removal Examination-Part III 1.) 2.) 3.) 4.) 5.) 6.) 7.) 8.) 9.) 10.) 11.) 12.) 13.) 14.) 15.) 16.) 17.) 18.) 19.) 20.) 21.) 22.) 23.) 24.) 25.) 26.) 27.) 28.) 29.) 30.) 342 3 C. 24 m B. 5.4 B. 16 cm D. 0.4 C. 20 kg C. 13 A. 14 C. 90o A. 12 C. 3x – 4y – 5 = 0 A. 2 C. 4x – 7 = 0 A. 5x + 4y = 41 A. 144 B. 2046 D. 14.3 D. 2cos2x - 1 B. 210 Joules C. 6.00 C. 0.66 hp A. 57.36 m higher D. 42.95 ft B. 0.20 C. x2y3 + y = c B. 1.5% A. P7,709.1 C. 60.0o D. 175 mm B. P3 668 A. Principle of Transmissibility SOLUTIONS 1. LxWxH 4m x 3m x 2m = 24m3 Ans. 24m3 2. A (x) + B (y) = C √$A2$ + $B2$ 3(2) + 4(3) + 9 √9 + 16 Ans. 5.4 3. x2 + (x +14)2 = 342 x2 + x2 + 28x +196 = 1156 2x2 + 28x - 960 = 0 x = 16 cm Ans. 16 cm 4. 5 sec2x = 2 1 sec2x = cos ^2(x) = 5 2 x = 21.1051 1 – sin2(21.1051) = 0.4 Ans. 0.4 5. OMB: 100 = W + P Solute Balance: 100(0.04) = 0.05P P = 80 kg 100 – 80 = W W = 20 kg Ans. 20 kg 6. (−) = n = 13 Ans. 13 7. y = kx 10 = k(5) when x = 7 y = 2(7) = 14 343 k=2 Ans. 14 8. A + B + C = 180 A+B=C A – B = 2/3C 2C = 180 C = 90 Ans. 90oC 9. LR = 4a 4a = 12 Ans. 12 10. 3y = 12 – 4x 4 y=- x+4 3 4 m1 = - 3 3 so m2 should be equal to 4 1 (m1 = -m2) Ans. 3x – 4y – 5 = 0 11. a 2 = b2 + c 2 36 = 32 + c2 4 = c2 c=2 Ans. 2 12. y = 2x2 – 7x + 5 axis of symmetry (y’) : 4x – 7 = 0 Ans. 4x – 7 = 0 13. C (0,0) 4 m1 = 5 5 pt (5,4) 5 m2 = - 4 y – 4 = - (x – 5) 4 4y – 16 = -5x + 25 Ans. 5x + 4y = 4 14. (5 – 1!) 3! = 144 Ans. 144 344 15. S= a1 (r n− 1) r−1 = 2 (210− 1) 2−1 = 2046 Ans. 2046 16. AB = 15 cm BC = 18 cm AC = 24 cm Ans. 14.3 cm 17. cos4x – sin4x = (cos2x + sin2x)(cos2x – sin2x) = 1 (cos2x - sin2x) = 1 (cos2x – (1 - cos2x)) = 2cos2x – 1 Ans. 2cos2x – 1 18. m = 200 g V1 = 20 m/s V2 = 50 m/s 1 1 1 2 KE = 2 m(v22 - v12) = 2 200(1000)((50 - 202) = 210 Joules Ans. 210 J 19. √22 + 42 + 42 = 6 Ans. 6 20. m = 150 kg PE = mgh = h = 20 m 150kg (9.81m/s2) 20m 60sec t = 1 min = 290.5 W = 0.66 hp Ans. 0.66 hp 21. V2 = Vo2 + 2gS 21.92 = 2g(97.5) g = 2.4595 27.62 = 2(2.4595)(S) S = 154.8583 ΔS = 154.8583 – 97.5 ΔS = 57.36 m Ans. 57.36 m 22. distance = ? m = 3000 lb v = 30 mi/h coefficient of friction = 0.70 Ans. 42.95 ft 345 23. angle = 250 T = 100N Coefficient of 0.20 Ans. 0.20 23. y∫ ydy = ∫ 3x 2 dx y2 = x3 + C y2 = 2x3 + C 2 Ans. y2 = 2x3 + C 24. 2xy3dx + (1+3x2y2)dy = 0 Ans. x2y3 + y =C 25. 12000 + 5000[1−(1+i)−10 i](1 + i)−4 = 4000[1−(1+i)−18 i](1 + i)−8 i = 1.54% Ans. 1.5% 26. Uniform decrease of P200 per year Initial Amount = P4,000 Final Amount = P2,200 t = 11 years t = 20 years 27. Index of refraction = 1.52 Angle = 60o Ans. P7,709.1 Ans. 60.0o 28. turns = 20 diameter = 20 mm mean radius = 90 mm load = 2.5kN G = 83 GPa Ans. 175 mm 29. Co = P53,000 + P1,500 = P54,500 CL = P5,000 d = (P54,500 – P5,000)/F/A, 6.5%,10 = P3,668 Ans. P3,668 346