

ACS Scholarship Exam
North Central College
May 24, 2008

Problem Solving. Show your work on these problems as partial credit is awarded for partially correct answers. You have 75 minutes.

INFORMATION THAT MAY BE OF USE TO YOU IN THE EXAM

$$N_A = 6.022 \times 10^{23} / \text{mol}$$

$$R = 8.31447 \text{ J}/(\text{mol} \cdot \text{K}) \text{ or } 0.08206 \text{ L atm}/(\text{mol} \cdot \text{K})$$

Order	Integrated Rate Law	Half-Life	other kinetics equations
0	$[A]_t = -kt + [A]_0$	$[A]_0/2k$	$k = Ae^{-E_a/RT}$
1	$\ln[A]_t = -kt + \ln[A]_0$	$0.693/k$	$\ln k = \ln A - E_a/RT$
2	$1/[A]_t = kt + 1/[A]_0$	$1/k[A]_0$	$\ln \frac{k_2}{k_1} = \frac{E_a}{R} \left[\frac{1}{T_1} - \frac{1}{T_2} \right]$

Enthalpy Changes Involving H₂O

Per Mole		Per Gram	
ΔH_{fus} (at 0°C)	6.02 kJ/mol	ΔH_{fus} (at 0°C)	334 J/g
ΔH_{vap} (at 100°C)	40.7 kJ/mol	ΔH_{vap} (at 1000°C)	2260 J/g
Molar heat cap. (s)	37.6 J/mol°C	Specific heat (s)	2.09 J/g°C
Molar heat cap. (l)	75.4 J/mol°C	Specific heat (l)	4.18 J/g°C
Molar heat cap. (g)	33.1 J/mol°C	Specific heat (g)	1.84 J/g°C

Periodic Table

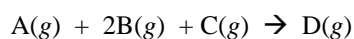
IA												0					
1 H 1.008												2 He 4.003					
	IIA											IIIA	IVA	VA	VIA	VIIA	
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	IIIB	IVB	VB	VIB	VIIIB	VIIIIB			IB	IIB	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.70	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57* La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226.0)	89** Ac (227)	104 Rf	105 Ha	106 Unh	107 Uns	108	109 Uue									

* 58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
** 90 Th 232.0	91 Pa (231)	92 U 238.0	93 Np (244)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)

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- 4) A solution prepared by dissolving 30.0 g of ethyl alcohol, C_2H_5OH , in 50.0 g of carbon tetrachloride, CCl_4 , has a density of 1.28 g/mL. Calculate
- the weight per cent (%) of ethyl alcohol.
 - the mole fraction of ethyl alcohol.
 - the molality ($m = \text{mol/kg solvent}$) of ethyl alcohol.
 - the molarity ($M = \text{mol/L soln}$) of ethyl alcohol.

- 5) For the reaction



the following data were obtained at constant temperature:

Experiment	Initial [A] (mol/L)	Initial [B] (mol/L)	Initial [C] (mol/L)	Initial Rate (mol/L·s)
1	0.0500	0.0500	0.0100	6.25×10^{-3}
2	0.1000	0.0500	0.0100	1.25×10^{-2}
3	0.1000	0.1000	0.0100	5.00×10^{-2}
4	0.0500	0.0500	0.0200	6.25×10^{-3}

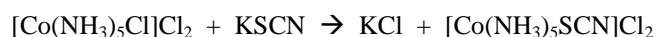
- What is the order with respect to each reactant?
- Write the rate law.
- What is the overall order?
- Calculate k .

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THESE LAST THREE QUESTIONS WILL BE USED TO DETERMINE TIEBREAKERS

- 6) In the analysis of organic compounds containing C, H, and O, the sample is burned in excess oxygen; this converts all of the carbon to CO₂ and all of the hydrogen to H₂O. These products then are separated and weighed. Analysis of a 2.00 mg vitamin C sample gives 3.00 mg and 0.816 mg of CO₂ and H₂O, respectively. What are the percentages of C, H, and O in vitamin C and determine its empirical formula. If the molar mass is determined to be ~180 g/mol, determine the molecular formula.

- 7) If you are asked to make 20 g of the compound [Co(NH₃)₅SCN]Cl₂ from [Co(NH₃)₅Cl]Cl₂ via the reaction



but you know that you can only expect a 55% yield and this is done using a 60% excess of KSCN. How much (in g) of each reagent should you use?

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- 8) Determine the pH of a 0.0025 M sodium carbonate solution if the pK_{a1} and pK_{a2} of H_2CO_3 are 6.37 and 10.25, respectively. Finally, determine the molar concentrations of all species in solution.