Chemistry 1220 - Su17
Practice Midterm 1

1. For which of the following combinations would the **solubility** be the **LOWEST**?

a) Na_2CO_3 in C_6H_{12}

b) CH_3CN in C_2H_5OH

c) HF in H_2O

d) Br_2 in CCl_4

e) KCl in H_2O

2. Which of the following, **a-d**, **INCORRECTLY** identifies the most important **solute-solvent** attractions in the given solution?

a) CsCl in NH_3	ion-dipole
b) CH_3CN in C_2H_5OH	London, dipole-dipole, H-bonding
c) CH_2Cl_2 in CCl_4	London
d) CH_3NH_2 in $CHCl_3$	London, dipole-dipole, H-bonding

e) Choose this answer if **ALL** of the above, **a-d**, are correctly identified.

3. The **heat of solution**, ΔH_{soln}, for a substance in water is -10.5 kJ/mol. The heat required to separate the solute particles is 155.0 kJ/mol. The heat required to separate the solvent particles is 210.0 kJ/mol. Estimate the **heat of solvation**, $\Delta H_{solvation}$ (also called the heat of mixing, ΔH_{mix}), for the solution process (kJ/mol)?

a) -365.0 b) 375.5 c) -375.5 d) 334.5 e) -334.5

4. The solubility of Na_2SO_4 in water is approximately 60 g per 100 mL at 30°C and 40 g per 100 mL at 100°C. Which of the following statements is **<u>FALSE</u>** for the process of solution of Na_2SO_4?

a) ΔH_{soln} is most likely **negative**.

b) The forces of attraction between solute and solvent are **stronger** than those between like particles.

c) The force of attraction between solute and solvent is **ion-dipole** type.

d) Solubility will most likely **<u>decrease</u>** with **increasing temperature**.

e) An **<u>increase</u>** in **entropy** (disorder) is **<u>necessary</u>** to facilitate the solubility of this substance.

5. Which of the following statements, **a-d**, about the effects of temperature and pressure on solubility is **<u>INCORRECT</u>**?

a) Solubility of most **ionic solids** in **water** generally **<u>increase</u>** with **increasing temperature**.

b) Solubility of a **gaseous** solute in **water** generally **<u>increases</u>** with **increasing pressure**.

c) Solubility of an **ionic** solid in **water** generally is **<u>not</u>** affected by **pressure**.

d) Solubility of a **gaseous** solute in **water** generally **<u>increases</u>** with **increasing temperature**.

e) Choose this answer if **ALL** statements, **a-d**, are **correct**.

6. An aqueous solution is 5.31**%** (by mass) glucose, $C_6H_{12}O_6$. What **<u>mass</u>** (in g) of solution is required to give 0.0109 moles of $C_6H_{12}O_6$? (At. Wts.: H = 1.008, C = 12.01, 0 = 16.00; Mol. Wts.: $C_6H_{12}O_6$ = 180.16, H_2O = 18.02)

a) 14.0 b) 28.0 c) 37.0 d) 45.0 e) 50.0

7. An aqueous solution has a mole fraction of glycerol ($C_3H_8O_3$) equal to 0.258. Its density is 1.1663 g/mL. What is the **mass percent** of glycerol in the solution?
(At. wts: H = 1.008, C = 12.01, O = 16.00; Mol. wts.: $C_3H_8O_3$ = 92.09, H_2O = 18.02)

a) 32.0% b) 64.0% c) 21.0% d) 76.0% e) 52%

8. The density of a 4.26 ***m*** aqueous solution of $(NH_4)_2SO_4$ is 1.2077 g/cm^3. What is the **molarity** of the compound? (Atomic weights: N = 14.01, S = 32.06, O = 16.00,
H = 1.008; Mol. wts.: $(NH_4)_2SO_4$ = 132.14, H_2O = 18.02)

a) 4.24 b) 4.03 c) 3.82 d) 3.60 e) 3.29

9. Which of the following aqueous solutions should have the **HIGHEST** osmotic pressure?

a) 0.012 M Na_2SO_4 at 25°C

b) 0.020 M $AlCl_3$ at 50°C

c) 0.020 M $AlCl_3$ at 25°C

d) 0.030 M KCl at 25°C

e) 0.030 M KCl at 50°C

10. A solution of heptane, C_7H_{16}, and octane, C_8H_{18}, has a total vapor pressure of 66.31 torr at 40 °C. The vapor pressure of pure heptane and pure octane are 91.96 torr and 50.92 torr, respectively, at 40 °C. What is the **mole fraction** of **octane** in the solution?

a) 0.800 b) 0.625 c) 0.500 d) 0.375 e) 0.200

11. A 12.0 g sample of a nonelectrolyte is dissolved in 80.0 g of water. The solution boils at 100.533 °C. What is the **molecular weight** of the substance? (K_b = 0.512°C/m)

a) 136 b) 144 c) 150 d) 156 e) 162

12. Which of the following statements is **FALSE**?

a) Volatile substances in ideal solutions obey Raoult's law.

b) The Tyndall effect describes the scattering of light by colloidal particles

c) Hydrophilic colloid particles tend to stay dispersed in water.

d) The boiling point of a solution of a nonvolatile solute is lower than that of the pure solvent.

e) Colligative properties of solutions containing nonvolatile and nondissociating solutes depend only on the concentration of solute particles and not the nature of the solute particles.

13. The balanced equation for the reaction of bromate ion with iodide in acidic solution is given by:

$$BrO_3^- + 9\,I^- + 6\,H^+ \rightarrow 3\,I_3^- + Br^- + 3\,H_2O$$

At a particular instant in time, the value of $-\Delta[I^-]/\Delta t$ is 5.4×10^{-4} M/s. What is the value of $-\Delta[H^+]/\Delta t$ in the same units?

a) 3.6×10^{-4}
b) 6.0×10^{-4}
c) 5.4×10^{-3}
d) 8.1×10^{-3}
e) 2.7×10^{-3}

14. A reaction is **3/2 order** in **A**, **second order** in **B** and **1/2 order** in **C**. The initial rate of the reaction is 1.0×10^{-6} M/sec when the initial concentrations are, $[A]_o = 0.0100$ M, $[B]_o = 0.0200$ M and $[C]_o = 0.0100$ M. What is the **rate constant** (in $M^{-3}s^{-1}$)?

a) 0.500
b) 25.0
c) 3.00×10^{-1}
d) 2.00×10^{-4}
e) 35.4

15. The following initial rate data were obtained at 25°C for the indicated reaction. What is the **rate law** for the reaction?

$$2\,A + B \rightarrow 4\,C$$

Exp.	[A] mol/L	[B] mol/L	rate of reaction
1	0.10	0.10	2.0×10^{-4}
2	0.20	0.10	8.0×10^{-4}
3	0.40	0.20	2.6×10^{-2}

a) rate = k[A] [B]
b) rate = $k[A]\,[B]^2$
c) rate = $k[A]^2[B]$
d) rate = $k[A]^2\,[B]^2$
e) rate = $k[A]^2[B]^3$

16. The reaction A → B + C is known to be **zero**-order in A with a rate constant of 5.0×10^{-2} M/s at 25°C. An experiment was run at 25°C where $[A]_0 = 1.0$ M. After 5.0 seconds, the **rate** (M/s) is

a) 5.0×10^{-2}
b) 2.5×10^{-2}
c) 1.25×10^{-2}
d) 1.0×10^{-3}
e) 5.0×10^{-3}

17. The reaction $A_2 \rightarrow B + C$ obeys the rate law

rate = $(1.0 \times 10^{-2}\ \text{min}^{-1})\ [A_2]$ at 298 K

How **long** (in min) will it take for the $[A_2]$ to decrease to 60% of its initial value?

a) 3.9 b) 5.1 x 10 c) 9.0 x 10

d) 6.5×10^2 e) 1.5×10^3

18. The reaction $A \rightarrow B + C$ obeys the rate law

$$\text{Rate} = (3.86 \times 10^{-2}\ \mathbf{M^{-1} \bullet s^{-1}})\ [A]^2$$

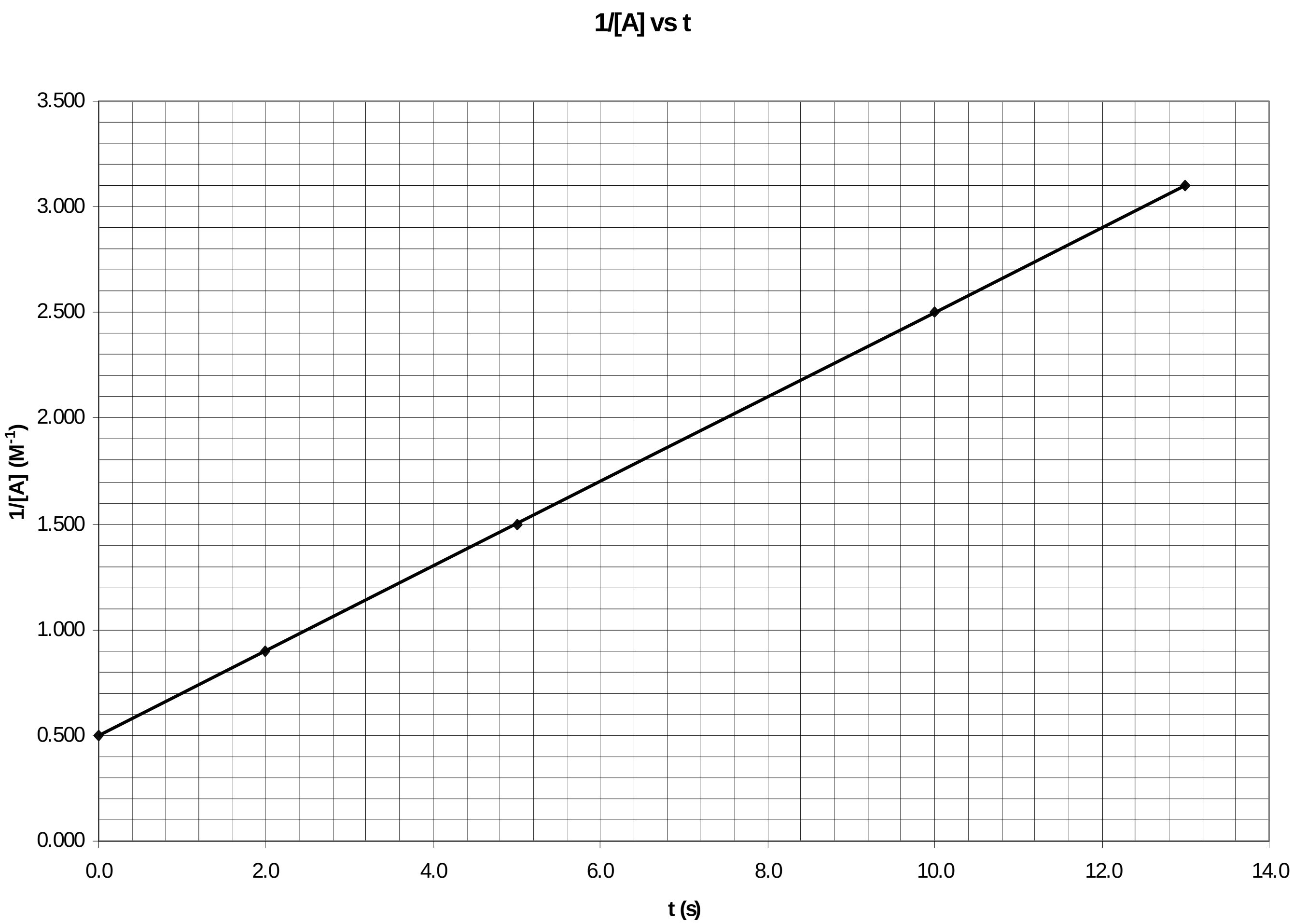
What **concentration** of **reactant** will remain after 74.4 sec for an initial concentration of 0.300 M?

a) 0.161 b) 0.200 c) 0.225 d) 0.245 e) 0.260

19. For the reaction A → Products, successive half-lives are observed to be 10.0 min, 5.0 min, and 2.5 min. At the beginning of the reaction, [A] was 0.10 M. The numerical value of the **rate constant** (in the units given in the problem) is

a) 0.069 b) 5.0×10^{-3} c) 1.0×10^2 d) 1.0 e) none of these

20. The following graph is obtained from concentration and time data. What is the **first** **half-life**, $t_{1/2}$ (secs) (at the start of the reaction)?



a) 2.50 b) 3.47 c) 5.00 d) 10.0 e) 0.347

21. Which of the following statements is (are) **TRUE**?

1) reaction rates depend on temperature, reactant structure, concentration of reactants and the presence of catalysts

2) catalysts shift reaction equilibria toward the side of the products

3) enzymes are catalysts in living organisms and increase rate by lowering the activation energy, E_a.

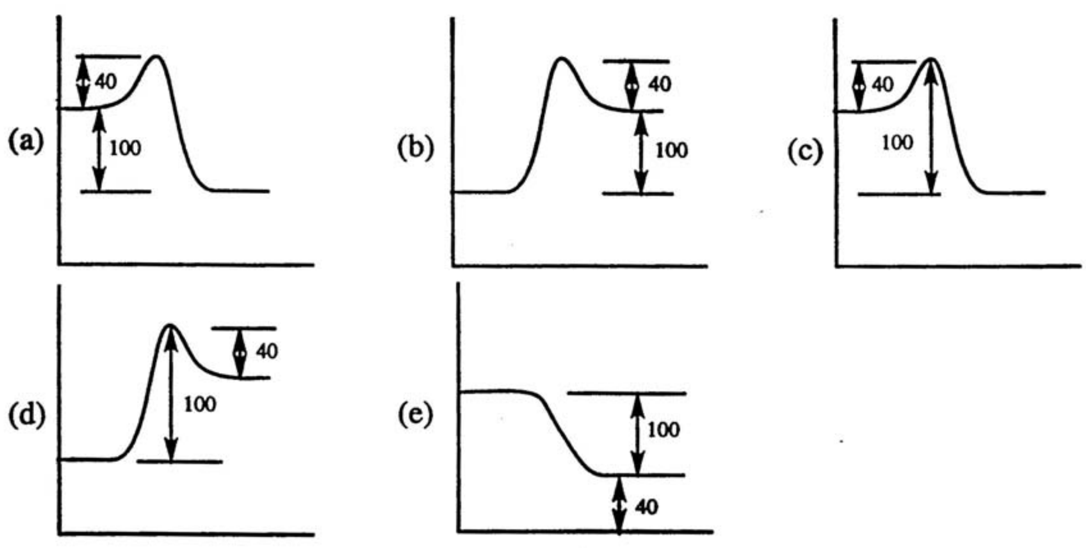
4) activation energy is required for both exothermic and endothermic reactions

5) a catalyst never has its concentration appear in the rate law

a) 1, 4 b) 3 c) 2, 5 d) 2, 4, 5 e) 1, 3, 4

22. A reaction has an **activation energy**, E_a, of 40 kJ and an overall energy change, ΔE, of -100 kJ. In each of the following potential energy diagrams, the horizontal axis is the reaction coordinate and the vertical axis is potential energy (in kJ). Which potential energy diagram best describes this reaction?

a) graph b) graph c) graph d) graph e) graph



23. Ozone is an important component of our upper atmosphere in blocking ultraviolet radiation but a pollutant at ground level. Ozone is believed to decompose according to the following mechanism. What would be the **rate expression** if the mechanism is correct?

$$2\ O_3 \rightarrow 3\ O_2 \quad \text{(balanced equation)}$$

$$O_3 \rightleftarrows O_2 + O \quad \text{(fast)}$$

$$O_3 + O \rightarrow 2\ O_2 \quad (\textbf{slow})$$

a) rate = k $[O_3]^2$

b) rate = k $[O_3]^2/[O_2]$

c) rate = k $[O_3]^2$ [O]

d) rate = k $[O_3]$ [O]

e) rate = k $[O_2]^3$

24. Consider the following hypothetical reaction and the established rate law. Select an acceptable mechanism.

$$A_2 + B_2 \rightarrow X + Y \qquad \text{rate} = k\,[A_2]\,[B_2]^{1/2}$$

a) $B_2 \rightarrow 2\ B$ (slow)

$B + A_2 \rightarrow C$ (fast)

$C + B \rightarrow X + Y$ (fast)

b) $A_2 \rightleftarrows C + X$ (fast)

$B_2 + C \rightarrow Y$ (slow)

c) $A_2 + B_2 \rightleftarrows C$ (fast)

$C \rightarrow X + Y$ (slow)

d) $A_2 \rightleftarrows 2\ A$ (fast)

$B_2 + A \rightarrow C$ (slow)

$C + A \rightarrow X + Y$ (fast)

e) $B_2 \rightleftarrows 2\ B$ (fast)

$A_2 + B \rightarrow C + X$ (slow)

$B + C \rightarrow Y$ (fast)

25. The rate constant for a reaction at 40.0°C is exactly three times that at 20.0°C. Calculate the Arrhenius **energy of activation**, $\mathbf{E_a}$, for the reaction.

a) 3.20 kJ/mol b) 30.0 kJ/mol c) 41.9 kJ/mol

d) 200 kJ/mol e) 366 kJ/mol

26. Which of the ractants and/or products do **<u>NOT</u>** appear in the properly written heterogeneous K_c expression for the reaction below?

$Al_2(SO_3)_3$ (s) + 6 H^+ (aq) ⇄ 2 Al^{3+} (aq) + 3 H_2O (ℓ) + 3 SO_2 (g)

a) $Al_2(SO_3)_3$(s) b) H^+ (aq) and Al^{3+} (aq)

c) $Al_2(SO_3)_3$(s) and H_2O(ℓ) d) H_2O(ℓ)

e) H^+ (aq), Al^{3+} (aq), $Al_2(SO_3)_3$(s) and H_2O(ℓ)

27. At equilibrium, which of the following is **<u>TRUE</u>**?

a) All chemical processes have ceased.

b) The rate constant for the forward reaction equals that of the reverse.

c) The rate of the forward reaction equals that of the reverse.

d) <u>Both</u> the rate of the forward reaction equals that of the reverse <u>and</u> the rate constant for the forward reaction equals that of the reverse.

e) none of the above

28. The equilibrium constant K_p for the following reaction at 1100°C is 1.56×10^{-51}. What is K_c?

$$BF_3(g) \rightleftarrows B(\mathbf{s}) + 3/2\ F_2(g)$$

a) 1.46×10^{-53} b) 1.64×10^{-52} c) 1.66×10^{-50}

d) 1.47×10^{-52} e) 1.30×10^{-54}

29. The equilibrium constant, K_1, for reaction (1) is 2.55×10^{1}. What is the value of the equilibrium constant, K_2, for equation (2)?

(1) $CH_4(g) + H_2O(g) \rightleftarrows CO(g) + 3\ H_2(g)$

(2) $2\ CO(g) + 6\ H_2(g) \rightleftarrows 2\ CH_4(g) + 2\ H_2O(g)$

a) 6.51×10^{2} b) 2.55×10^{1} c) 3.92×10^{-2}

d) 1.54×10^{-3} e) 6.02×10^{-5}

30. The K_c for the following reaction at 1000°C is 1.17. For a system with the concentrations $[CO_2] = 0.100$ M and $[CO] = 0.312$ M one can conclude (**to 3 sig. fig.**)

$$CO_2(g) + C(\mathbf{s}) \rightleftarrows 2\ CO(g)$$

a) the system is not at equilibrium and the reaction will proceed to the right
b) the system is not at equilibrium and the reaction will proceed to the left
c) the system is at equilibrium and no net change will occur

31. Consider the following reactions. In which case(s) will the reaction proceed more to the **LEFT** (towards **reactants**) by **decreasing temperature**?

1) $CO_2(g) + C(\mathbf{s}) \rightleftarrows 2\ CO(g)$ $\Delta H = 172.5$ kJ

2) $N_2(g) + 3\ H_2(g) \rightleftarrows 2\ NH_3(g)$ $\Delta H = -91.8$ kJ

3) $CO(g) + 2H_2(g) \rightleftarrows CH_3OH(g)$ $\Delta H = -21.7$ kJ

4) $N_2(g) + O_2(g) \rightleftarrows 2\ NO(g)$ $\Delta H = 181$ kJ

5) $2\ H_2O(g) \rightleftarrows 2\ H_2(g) + O_2(g)$ $\Delta H = 484.6$ kJ

a) 2, 3 b) 2, 4 c) 1, 4, 5 d) 3, 4 e) 3

32. For which of the following reactions is **product** formation favored by **high pressure** and **low temperature**?

1) $2\ NO_2(g) \rightleftarrows N_2(g) + 2\ O_2(g)$ $\Delta H = -66.4$ kJ

2) $CO_2(g) + C(\mathbf{s}) \rightleftarrows 2\ CO(g)$ $\Delta H = 172.5$ kJ

3) $H_2(g) + I_2(g) \rightleftarrows 2\ HI(g)$ $\Delta H = -9.4$ kJ

4) $N_2(g) + O_2(g) \rightleftarrows 2\ NO(g)$ $\Delta H = 181$ kJ

5) $CO(g) + 3\ H_2(g) \rightleftarrows CH_4(g) + H_2O(g)$ $\Delta H = -206.2$ kJ

a) 1 b) 2 c) 3 d) 4 e) 5

33. Consider the following reactions at equilibrium and determine which of the indicated changes will cause the reaction to proceed to the **right**. We are considering small changes in a substance (i.e. adding or removing small amounts)

1) $CO_2(g) + C(\mathbf{s}) \rightleftarrows 2\,CO(g)$ (add CO_2)

2) $CO(g) + 3\,H_2(g) \rightleftarrows CH_4(g) + H_2O(g)$ (remove CO)

3) $2\,CO_2(g) \rightleftarrows 2\,CO(g) + O_2(g)$ (add CO)

4) $N_2(g) + 3\,H_2(g) \rightleftarrows 2\,NH_3(g)$ (add nitrogen)

5) $CO(g) + 2H_2(g) \rightleftarrows CH_3OH(\ell)$ (remove CH_3OH)

a) 2, 3 b) 1, 4 c) 2, 4 d) 3, 4 e) 1, 4, 5

34. The Haber process, shown below, is one of the most important industrial processes in the world, as discussed in lecture. It has an equilibrium constant, K, of 3.8×10^8 and $\Delta H = -92$ kJ/mol at 25°C. Which of the following statements about this reaction at equilibrium is(are) **TRUE**?

$$N_2\,(g) + 3\,H_2\,(g) \rightleftarrows 2\,NH_3\,(g)$$

1) As temperature increases less NH_3 is obtained and K decreases.
2) Catalysts are added to speed the reaction and increase the concentration of NH_3 at equilibrium.
3) Raising the pressure by adding He will shift the reaction toward the product.
4) The reaction is not likely to occur as a single-step mechanism.
5) Decreasing the volume of the container at constant temperature will result in more NH_3.

a) 1, 2 b) 2, 3, 4 c) 2, 3, 5 d) 1, 4, 5 e) 1, 5

35. For the following reaction, 1.000 mole of C is placed in a 2.000 L flask and allowed to reach equilibrium, at 25°C. At equilibrium 0.7500 moles of C remains. What is the value of K_c?

$$2\,A\,(g) + B\,(g) \rightarrow 2\,C\,(g)$$

a) 7.200×10^{1} b) 6.944×10^{-3} c) 4.800×10^{1}

d) 1.389×10^{-2} e) 1.440×10^{2}

36. For the following system, 5.00 moles of A and 5.00 moles of B are placed in a **10.00** L flask and allowed to reach equilibrium, at a particular temperature. The value of K_c for this reaction is 1.10×10^{2}. What are the concentrations of **B** and **C** at equilibrium, in this order?

$$A\,(g) + B\,(g) \rightleftarrows 2\,C\,(g)$$

a) 0.080, 0.840 b) 0.420, 0.840 c) 0.500, 0.840

d) 0.500, 0.420 e) none of these

USEFUL INFORMATION

R = 0.08206 L-atm/mol-K = 8.3145 J/mol-K

Avogadro's number = 6.02×10^{23} particles/mole

$$P_A = X_A P_A^\circ \qquad \Delta P = X_B P_A^\circ \qquad \Delta T = iK_f m \qquad \Delta T = iK_b m \qquad \Pi = iMRT$$

$$\ln[A]_t = -kt + \ln[A]_0 \qquad [A]_t = -kt + [A]_0 \qquad \frac{1}{[A]_t} = kt + \frac{1}{[A]_0}$$

$$t_{\frac{1}{2}} = \frac{1}{k[A]_0} \qquad t_{\frac{1}{2}} = \frac{[A]_0}{2k} \qquad t_{\frac{1}{2}} = \frac{0.693}{k}$$

$$k = A\, e^{-E_a/RT} \qquad \ln(k) = -\left(\frac{E_a}{R}\right)\left(\frac{1}{T}\right) + \ln(A)$$

$$\ln\left(\frac{k_2}{k_1}\right) = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right) \qquad \log\left(\frac{k_2}{k_1}\right) = \frac{E_a}{2.303R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$$K_p = K_c\,(RT)^{\Delta n}$$

$$\textit{for}\quad ax^2 + bx + c = 0, \qquad x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1	1.008 **H** 1																	4.003 **He** 2
2	6.941 **Li** 3	9.012 **Be** 4											10.81 **B** 5	12.011 **C** 6	14.007 **N** 7	15.999 **O** 8	18.998 **F** 9	20.179 **Ne** 10
3	22.990 **Na** 11	24.305 **Mg** 12											26.98 **Al** 13	28.09 **Si** 14	30.974 **P** 15	32.06 **S** 16	35.453 **Cl** 17	39.948 **Ar** 18
4	39.098 **K** 19	40.08 **Ca** 20	44.96 **Sc** 21	47.88 **Ti** 22	50.94 **V** 23	52.00 **Cr** 24	54.94 **Mn** 25	55.85 **Fe** 26	58.93 **Co** 27	58.69 **Ni** 28	63.546 **Cu** 29	65.38 **Zn** 30	69.72 **Ga** 31	72.59 **Ge** 32	74.92 **As** 33	78.96 **Se** 34	79.904 **Br** 35	83.80 **Kr** 36
5	85.47 **Rb** 37	87.62 **Sr** 38	88.91 **Y** 39	81.22 **Zr** 40	92.91 **Nb** 41	95.94 **Mo** 42	98 **Tc** 43	101.07 **Ru** 44	102.91 **Rh** 45	106.42 **Pd** 46	107.87 **Ag** 47	112.41 **Cd** 48	114.82 **In** 49	118.69 **Sn** 50	121.75 **Sb** 51	127.60 **Te** 52	126.90 **I** 53	131.39 **Xe** 54
6	132.91 **Cs** 55	137.33 **Ba** 56	138.91 **La** 57	178.39 **Hf** 72	180.95 **Ta** 73	183.85 **W** 74	186.21 **Re** 75	190.23 **Os** 76	192.22 **Ir** 77	195.08 **Pt** 78	196.97 **Au** 79	200.59 **Hg** 80	204.38 **Tl** 81	207.2 **Pb** 82	208.98 **Bi** 83	209 **Po** 84	210 **At** 85	222 **Rn** 86
7	223 **Fr** 87	226.03 **Ra** 88	227.03 **Ac** 89	261 **Rf** 104	262 **Ha** 105	263 **Sg** 106	262 **Ns** 107	265 **Hs** 108	266 **Mt** 109	269 110	272 111	277 112						

Lanthanide Series	140.12 **Ce** 58	140.91 **Pr** 59	144.24 **Nd** 60	145 **Pm** 61	150.36 **Sm** 62	151.96 **Eu** 63	157.25 **Gd** 64	158.93 **Tb** 65	162.50 **Dy** 66	164.93 **Ho** 67	167.26 **Er** 68	168.93 **Tm** 69	173.04 **Yb** 70	173.04 **Lu** 71
Actinide Series	232.04 **Th** 90	231.04 **Pa** 91	238.03 **U** 92	237.05 **Np** 93	**Pu** 94	**Am** 95	**Cm** 96	**Bk** 97	**Cf** 98	**Es** 99	**Fm** 100	**Md** 101	**No** 102	**Lr** 103

A PERIODIC CHART OF THE ELEMENTS
(Based on ^{12}C)

Chemistry 1220

Answers to Practice Midterm 1

1) A	11) B	21) E	31) C
2) D	12) D	22) A	32) E
3) C	13) A	23) B	33) B
4) E	14) B	24) E	34) D
5) D	15) E	25) C	35) E
6) C	16) A	26) C	36) A
7) B	17) B	27) C	
8) E	18) A	28) D	
9) B	19) B	29) D	
10) B	20) A	30) A	