**Chem 112 spring 2011** **Exam 2 A** **10:00am/Odago**
03/24/2011

***Attempt all the questions in part A and any two questions in part B showing your steps clearly***

1. Which of the following is <u>not</u> a colligative property?
   a) osmotic pressure b) vapor pressure lowering
   c) freezing-point depression d) lattice energy
   e) boiling-point elevation

2. What is the molality of a solution prepared by dissolving 0.138 mol of chloroform, $CHCl_3$, in 409 g of toluene, $C_6H_5CH_3$?

   a) 0.337 *m* b) 0.0310 *m* c) 0.0405 *m*
   d) 0.0301 *m* e) 0.564 *m*

3. A solution consisting of 0.210 mol of methylbenzene (solute), $C_6H_5CH_3$, in 248 g of nitrobenzene (solvent), $C_6H_5NO_2$, freezes at 0.1°C. Pure nitrobenzene freezes at 6.0°C. What is the freezing-point depression constant of nitrobenzene?

   a) 0.3°C/*m* b) 3.5°C/*m* c) 28°C/*m* d) 7.0°C/*m*
   e) 14.0°C/*m*

4. A cucumber is placed in a concentrated salt solution. What is most likely to happen?
   a) Water will flow from the cucumber to the solution.
   b) Water will flow from the solution to the cucumber.
   c) Salt will flow into the cucumber.
   d) Salt will precipitate out.
   e) No change will occur.

5. A 2.2-g sample of a small protein having a molecular weight of 42,000 g/mol is dissolved in 45.6 mL of water at 23°C. What is the osmotic pressure of the solution? ($R$ = 0.0821 L · atm/(K · mol))

   a) 0.028 mmHg b) 1.6 mmHg c) 21 mmHg d) 27000 mmHg
   e) 890 mmHg

6. For a 0.001 *M* solution of $FeCl_3$, the van't Hoff factor ($i$) would be about

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

7. What is the freezing point of an aqueous 1.18 *m* $MgCl_2$ solution? ($K_f$ for water is 1.858°C/*m*.)
   a) –2.2°C b) 2.2°C c) –6.6°C d) 6.6°C e) 0.0°C

8. If a reaction is second-order in a reactant, when the concentration of the reactant is decreased by a factor of 2, the reaction rate will
   a) remain constant. b) decrease by a factor of 1/4.
   c) decrease by a factor of 1/2. d) double.
   e) quadruple.

9. The following data were obtained in a kinetics study of the hypothetical reaction

   A + B + C → products.

| $[A]_0$ (*M*) | $[B]_0$ (*M*) | Initial Rate ($10^{-3}$ *M*/s) |
|---|---|---|
| 0.4 | 0.4 | 160 |
| 0.2 | 0.4 | 80 |
| 0.6 | 0.1 | 15 |
| 0.2 | 0.1 | 5 |
| 0.2 | 0.2 | 20 |

   Using the initial-rate method, what is the order of the reaction with respect to B?

   a) third-order b) second-order c) zero-order
   d) first-order e) impossible to tell from the data given

10. The following data were obtained for the hypothetical reaction 2A + B → products.

| $[A]_0$ (*M*) | $[B]_0$ (*M*) | Initial Rate (*M*/s) |
|---|---|---|
| 0.2 | 0.1 | 5 |
| 0.2 | 0.2 | 20 |
| 0.6 | 0.1 | 45 |

   What is the overall order of this reaction?

   a) 0 b) ½ c) 1 d) 3 e) 4

11. The reaction A → products is first-order in A. If the concentration of A is cut in half, the half-life of the reaction will
   a) double. b) decrease by a factor of 1/2.
   c) decrease by a factor of 1/4. d) remain constant.
   e) quadruple.

12. For a reaction of the form A → products, a plot of 1/[A] versus time is linear for a reaction of which order?

a) zero b) first c) second d) third e) fourth

13. What would happen if the kinetic energy of the reactants were not enough to provide the needed activation energy?
a) The products would be produced at a lower energy state.
b) The rate of the reaction would tend to increase.
c) The activated complex would be converted into products.
d) The reactants would continue to exist in their present form.
e) The products would form at an unstable energy state.

14. For a given reaction, the rate constant, *k*, was determined at different temperatures. To obtain the activation energy, one should plot

a) *k* vs. *T*. b) log *k* vs. *T*. c) ln *k* vs. *T*. d) *k* vs. 1/*T*.
e) ln *k* vs. 1/*T*.

15. Determine the molecularity of the following elementary reaction: $O_3 \rightarrow O_2 + O$.
a) unimolecular b) bimolecular c) termolecular
d) quadmolecular e) cannot be determined

16. What is the mole fraction of urea in a solution that contains 3.4 mol of urea and 5.4 mol of water?

a) 0.61 b) 0.39 c) 0.49 d) 0.77 e) 0.59

17. What type of colloid is formed when a solid is dispersed in another solid?

a) foam b) aerosol c) emulsion d) sol e) gel

18. Which of the following corresponds to the correct integrated expression for a first-order reaction?

a) $\frac{1}{A} - \frac{1}{B} = kt$ b) $\frac{1}{A} - \frac{1}{A_0} = kt$ c) $\frac{1}{A_0} - \ln\frac{A}{A_0} = kt$

d) $\ln\frac{[A]_t}{[A]_o} = \text{- kt}$ e) $t_{1/2} = \frac{0.693}{k}$

19. In a first-order reaction, the half-life is 8640 seconds. What is the rate constant?

a) $8.02 \times 10^{-5}\ s^{-1}$ b) $1.16 \times 10^{-4}\ s^{-1}$ c) $5990\ s^{-1}$
d) $0.289\ s^{-1}$ e) $4.81 \times 10^{-3}\ s^{-1}$

20. For the formation of 1 mol of nitrosyl chloride at a given temperature, $\Delta H = -41$ kJ.
$NO(g) + \frac{1}{2}Cl_2(g) \rightarrow NOCl(g)$

The activation energy for this reaction is 57 kJ/mol. What is the activation energy for the reverse reaction?

a) –41 kJ/mol b) 16 kJ/mol c) 57 kJ/mol
d) 98 kJ/mol e) –98 kJ/mol

21. Which of the following statements is <u>incorrect</u> concerning a catalyst?

a) A catalyst decreases the activation energy of a reaction.
b) A catalyst provides an alternative reaction mechanism.
c) A catalyst alters the equilibrium distribution of reactants and products.
d) A catalyst may appear in the rate law for a reaction.
e) There is no net consumption of a catalyst in a reaction.

22. What is the $K_c$ equilibrium-constant expression for the following equilibrium?
$NiO(s) + H_2(g) \rightleftharpoons Ni(s) + H_2O(g)$

a) $\frac{[NiO][H_2]}{[Ni][H_2O]}$ b) $\frac{[Ni][H_2O]}{[NiO][H_2]}$ c) $\frac{[Ni][H_2O]}{[H_2]}$ d) $\frac{[H_2]}{[H_2O]}$
e) $\frac{[H_2O]}{[H_2]}$

23. For which of the following equilibria does $K_c = K_p$?

a) $CO(g) + 3H_2(g) \rightleftharpoons CH_4(g) + H_2O(g)$
b) $HBr(g) \rightleftharpoons \frac{1}{2}H_2(g) + \frac{1}{2}Br_2(l)$
c) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
d) $CaO(s) + CO_2(g) \rightleftharpoons CaCO_3(s)$
e) $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$

24. Carbon tetrachloride may react with oxygen to produce chlorine and carbonyl chloride.
$2CCl_4(g) + O_2(g) \rightleftharpoons 2COCl_2(g) + 2Cl_2(g)$; $K_c = 9.9 \times 10^{51}$

What is $K_c$ for the following equilibrium?

$COCl_2(g) + Cl_2(g) \rightleftharpoons CCl_4(g) + \frac{1}{2}O_2(g)$

a) $-9.9 \times 10^{51}$ b) $1.0 \times 10^{-26}$ c) $9.9 \times 10^{-51}$ d) $1.0 \times 10^{-52}$
e) $5.0 \times 10^{-53}$

25. Given the reactions and their equilibrium constants,

$A \rightleftharpoons 2B$ $K_1 = 2$

$B \rightleftharpoons C$ $K_2 = 3$

What is the equilibrium constant ($K_3$) for the reaction below.

$A \rightleftharpoons 2C$ $K_3$

a) 18 b) 6 c) 5 d) 7 e) 1.5

**_END OF SECTION A_**

***SECTION B***

***(Answer any two questions in this section within the spaces provided showing your work clearly for partial credit where appropriate 10 points each)***

26. Thyroxine, an important hormone that controls the rate of metabolism in the body, can be isolated from the thyroid gland. If 0.456 g of thyroxine is dissolved in 10.0 g of benzene, the freezing point of the solution could be measured as 5.144°C. Pure benzene freezes at 5.444°C and has a value for the molal freezing-point-depression constant of $K_f$ of 5.12°C/$m$. What is the approximate molar mass of thyroxine?

27. The rate constant for a reaction at 40.0°C is exactly 3 times that at 20.0°C. Calculate the Arrhenius energy of activation for the reaction.

28. Consider the equilibrium system involving the decomposition of iodine monobromide.

$$2\mathbf{IBr}\ (g) \rightleftharpoons \mathbf{Br_2}\ (g) + \mathbf{I_2}\ (g).$$

a) What is the equilibrium constant expression

$K_c$ =

b) Given that the equilibrium constant $K_c$=1.13 x $10^{-2}$ at 516 K. Calculate the equilibrium concentrations will be if the flask originally contains 0.227 M iodine monobromide

Equilibrium concentrations are;

[IBr] = [$Br_2$] = [$I_2$] =

**Equations and constants**

Gas law constant, R: 0.0821 L atm $mol^{-1}$ $K^{-1}$

8.314 J $mol^{-1}$ $K^{-1}$

Ideal gas law: PV = nRT

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

Integrated rate laws:

$$\ln\frac{[A]_t}{[A]_o} = -\text{kt}$$

$$\frac{1}{[A]_t} = \text{kt} + \frac{1}{[\text{A}]_\text{o}}$$

$$[A] = -kt + [A]_\text{o}$$

Quadratic equation: $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$$\pi = MRT$$

Arrhenius equation: $k = \text{A e}^{\frac{-E_a}{RT}}$ or $\ln\frac{k_2}{k_1} = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$

Half life formulae

$$t_{1/2} = \frac{1}{k[\text{A}]_\text{o}}$$

$$t_{1/2} = \frac{0.693}{k} \qquad t_{1/2} = \frac{[\text{A}]_\text{o}}{2k}$$

$\Delta T_b = K_b\text{m}$ or $\Delta T_b = iK_b\text{m}$

$\Delta T_f = K_f\text{m}$ or $\Delta T_f = iK_f\text{m}$

1.0 atm = 760 mmHg(or torr)