MC, Chem1B, Fall 2018, Test 2 Name KEY

Read questions carefully before answering. No outside paper is allowed. Write **set up equation** for a mathematical problem, then put the raw data with **units**, before showing the calculation. Use the reverse side of your answer paper as scratch. Use the periodic table and important constants charts provided. (Total points = 44 + (22x3=)66 =110).

Show your calculation with set up and units (when appropriate)

1) An aqueous solution contains 3.62 mass % of NaOCl. Calculate (a) the molality (4 pts.) of NaOCl in the solution. (4 pts.)

1) 0.49 m

Assume solution mass = 100 g = 0.1 kg

Mass of solute = mass NaOCl = 3.62 g.

$3.62\,g \times \frac{1\,mole}{74.5\,g_{NaOCl}} = 0.049\,mol_{NaOCl}$

$molality = \frac{0.049\,mol_{NaOCl}}{0.1\,kg\ (soln\ (NO))} = 0.49\,m$

molality = mole of solute / wt. of solvent in Kg

$= \frac{3.62\,g \times \frac{1\,mol}{(23+16+35.45)\,g}}{(100-3.62)\,g \times \frac{1\,kg}{1000\,g}}$

$= \frac{0.04862\,mol}{0.09638\,kg} = 0.504\,\frac{mol}{molal}$

(b) Calculate the mole fraction of NaOCl in the aqueous solution(4 pts.)

mass of water : 100 g - 3.62 g = 96.38 g.

$96.38\,g \times \frac{1\,mol}{18\,g_{H_2O}} = 5.35\,mol_{H_2O}$

$X_{NaOCl} = \frac{0.049\,mol_{NaOCl}}{0.049\,mol_{NaOCl} + 5.35\,mol_{H_2O}} = 9.1 \times 10^{-3}$

2) What mass (in kilogram) of $CaCl_2$ is needed to decrease FP of 11000.0 g of water to - 5.5 °C. (Assume $CaCl_2$ dissolves completely and it has an ideal van't Hoff factor. K_{fp} for water is - 1.86 °C/m.) *8 pts.)

2) 1.21 Kg $CaCl_2$

$CaCl_2 \longrightarrow Ca^{2+} + 2Cl^-$

$i = 3$

$\Delta T_f = -5.5°C - 0°C$

$= -5.5°C$

$\Delta T_f = K_f \times m \times i$

$\Rightarrow m = \frac{|\Delta T_f|}{K_f \times i} = \frac{-5.5°C}{-1.86°C/m \times 3} = 0.99\,m$

$m = \frac{moles\ of\ CaCl_2}{kg\ water} \Rightarrow moles\ of\ CaCl_2 = m \times kg\ water$

$= 0.99\,m \times 11000.0\,g \times \frac{1\,kg}{1000\,g}$

$= 10.89\ moles$

$mass\ of\ CaCl_2 = 10.89\,mol \times \frac{111\,g}{1\,mol} \times \frac{1\,kg}{1000\,g} = 1.21\,kg\ CaCl_2$

Rate = $K.[A]^m[B]^n$

3) The initial rate of the reaction A + B -----> C was measured at several different concentrations of the reactants. Following formal methods, (a) calculate the rate law for the reaction (6 pts.) and (b) The magnitude of the rate constant (4 pts.).

3) $4\times10^{-3}\ M^{-1}s^{-1}$

	Initial Concentrations		Initial Rate
Experiment	[A] (M)	[B] (M)	(M s^{-1})
1	0.10	0.10	4.0×10^{-5}
2	0.10	0.20	4.0×10^{-5}
3	0.20	0.10	16.0×10^{-5}

$$\frac{\text{Rate 2}}{\text{Rate 1}} = \frac{K[0.1]^m[0.20]^n}{K[0.1]^m[0.1]^n} = \left(\frac{0.2}{0.1}\right)^n = 2^n = \frac{4.0\times10^{-5}}{4.0\times10^{-5}} = 1 \Rightarrow 2^n = 1 \Rightarrow \log 2^n = \log 1$$

$$n.\log 2 = \log 1$$

$$n = 0 \checkmark$$

$$\frac{\text{Rate 3}}{\text{Rate 1}} = \frac{K[0.2]^m[0.1]^n}{K.[0.1]^m.[0.1]^n} = \left(\frac{0.2}{0.1}\right)^m = 2^m = \frac{16\times10^{-5}}{4\times10^{-5}} = 4 \Rightarrow 2^m = 4 \Rightarrow \log 2^m = \log 4$$

$$m.\log 2 = \log 4$$

$$m = 2 \checkmark$$

$\Rightarrow$ Rate law : rate = $K.[A]^2 \Rightarrow K = \frac{\text{rate}}{[A]^2} = \frac{4\times10^{-5}\ M.s^{-1}}{(0.1\ M)^2} = 4\times10^{-3}\ M^{-1}.s^{-1}$ ✓

4) The reaction 2 $NO_2(g)$ -----> $2NO(g) + O_2(g)$ is 2nd order in [NO_2] at 300°C with $k = 0.543\ M^{-1}\ s^{-1}$; If in a closed container, the initial concentration of NO_2 = 0.05 M then calculate the concentration of NO_2 after half an hour at that temperature (6 pts.). [Note: For 2nd order kinetics: $1/[A]_t = k\ .\ t + 1/[A]_0$]

4) $1.00\times10^{-3}\ M$

$$\frac{1}{[A]_t} = K.t + \frac{1}{[A]_0}$$

$$\frac{1}{[A]_t} = (0.543\ M^{-1}s^{-1}) \times \left(30\ m \times \frac{60\ s}{1\ m}\right) + \frac{1}{0.05\ M}$$

$$= 977.4\ M^{-1} + 20\ M^{-1}$$

$$= 997.4\ M^{-1}$$

$$\Rightarrow \frac{1}{[A]_t} = 997.4\ M^{-1}$$

$$[A]_t = \frac{1}{997.4\ M^{-1}} = 1.00\times10^{-3}\ M \checkmark$$

5) In the reaction N_2 (g) + 3 H_2 (g) ↔ 2 NH_3 (g), if the K_c = 9.60 at 573 K, then calculate the Kp at this temperature (4 pts.). 5) 4.34×10^{-3}

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

$\Delta n = 2 - (1+3) = -2$.

$K_p = 9.60 \times (0.0821 \times 573)^{-2}$

$= 4.34 \times 10^{-3}$ ✓

6) In the equilibrium rxn. Butane (g) ↔ Isobutane (g), assume equlibrium has reached in a 1.0 L flask with [Butane] = 0.5 M and [Isobutane] = 1.23 M at 298 K. The equlibrium constant for the reaction = 2.5 and afterwards 1.5 mol of Butane was added to the mixture. Calculate the new values of [Butane] and [Isobutane] when equilibrium was reestablished? Use ICE chart if needed (8 pts.) 6) 0.923 M, 0.153 M

	Butane (g)	⇌	Isobutane (g)
I:	2M		1.23 M
C:	x		x
E:	2M − x		1.23 + x ✓

$K_c = \frac{[\text{Isobutane}]}{[\text{Butane}]} = \frac{1.23+x}{2-x} = 2.5$ −2

$1.23 + x = 2.5 \times (2-x)$

$1.23 + x = 5 - 2.5x$

$3.5x = 3.77$

$x = \frac{3.77}{3.5} = 1.077$ ✓

$[\text{Butane}]_{eq} = 2 - 1.077 = 0.923$ M ✓

$[\text{Isobutane}]_{eq} = 1.23 + 1.077 = 2.307$ M $= 0.153$ M

MULTIPLE CHOICE. On your scantron, start answering from the bubble number same as the question number. Select the one alternative that best completes the statement or answers the question (3 pts each).

7) The process of solute particles being surrounded by solvent particles is known as _____. 7) B

A) agglutination
B) solvation
C) agglomeration
D) salutation
E) dehydration

8) In a saturated solution of a salt in water, _____. 8) E

A) the rate of dissolution > the rate of crystallization
B) addition of more water causes massive crystallization
C) the rate of crystallization > the rate of dissolution
D) seed crystal addition may cause massive crystallization
E) the rate of crystallization = the rate of dissolution

9) Calculate the molality of a 10.0% (by mass) aqueous solution of hydrochloric acid. 9) D A

A) 3.05 m
B) 0.274 m
C) 4.33 m
D) 2.74 m
E) The density of the solution is needed to solve the problem.

10) A 0.100 m solution of which one of the following solutes will have the lowest vapor pressure? 10) A B

A) NaCl
B) $Al(ClO_4)_3$
C) $Ca(ClO_4)_2$
D) sucrose
E) $KClO_4$

11) A 1.35 m aqueous solution of compound X had a boiling point of 101.4°C. Which one of the following could be compound X? The boiling point elevation constant for water is 0.52°C/m. 11) E

A) $C_6H_{12}O_6$ 1
B) CH_3CH_2OH 1
C) Na_3PO_4 4
D) $CaCl_2$ 3
E) KCl 2

$\Delta T = K \times m \times i$

Na_3PO_4
$3Na^+ + PO_4^{3-}$

12) Colligative properties of solutions include all of the following except _____. 12) E B

A) depression of the freezing point of a solution upon addition of a solute to a solvent
B) the increase of reaction rates with increase in temperature
C) elevation of the boiling point of a solution upon addition of a solute to a solvent
D) depression of vapor pressure upon addition of a solute to a solvent
E) an increase in the osmotic pressure of a solution upon the addition of more solute

13) Which one of the following is <u>not</u> a valid expression for the rate of the reaction below? 13) E

$$4NH_3 + 7O_2 \rightarrow 4NO_2 + 6H_2O$$

A) $\frac{1}{4}\frac{\Delta[NO_2]}{\Delta t}$

B) $-\frac{1}{7}\frac{\Delta[O_2]}{\Delta t}$

C) $\frac{1}{6}\frac{\Delta[H_2O]}{\Delta t}$

D) $-\frac{1}{4}\frac{\Delta[NH_3]}{\Delta t}$

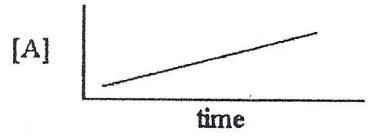
E) All of the above are valid expressions of the reaction rate.

14) Of the units below, _____ are appropriate for a first- order reaction rate constant. 14) B

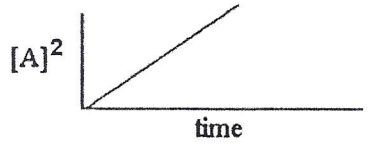
A) $M\ s^{-1}$
B) s^{-1}
C) $M^{-1}\ s^{-1}$
D) $L\ mol^{-1}\ s^{-1}$
E) mol/L

15) Which one of the following graphs shows the correct relationship between concentration and time for a reaction that is second order in [A]? 15) D

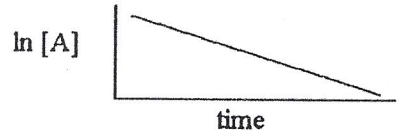
A)



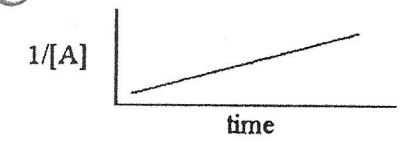
B)



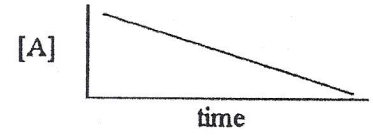
C)



D)



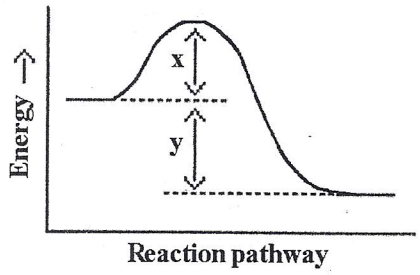
E)



16) As the temperature of a reaction is increased, the rate of the reaction increases because the _____. 16) C

A) reactant molecules collide less frequently and with greater energy per collision
B) activation energy is lowered
C) reactant molecules collide more frequently and with greater energy per collision
D) reactant molecules collide less frequently
E) reactant molecules collide more frequently with less energy per collision

17) Which energy difference in the energy profile below corresponds to the activation energy for the forward reaction? 17) A



A) x B) y C) y - x D) x - y E) x + y

18) How does the reaction quotient of a reaction (Q) differ from the equilibrium constant (K_{eq}) of the same reaction? 18) B

A) K does not depend on the concentrations or partial pressures of reaction components.
B) Q is the same as K_{eq} when a reaction is at equilibrium.
C) Q does not depend on the concentrations or partial pressures of reaction components.
D) K_{eq} does not change with temperature, whereas Q is temperature dependent.
E) Q does not change with temperature.

19) Given the following reaction at equilibrium, if $K_c = 6.44 \times 10^5$ at 230.0°C, K_p = _____. 19) D

$$2NO\ (g) + O_2\ (g) \rightleftharpoons 2NO_2\ (g)$$

A) 6.44×10^5
B) 2.66×10^6
C) 2.67×10^7
D) 1.56×10^4
E) 3.67×10^{-2}

$T = 503.15\ K$
$R = \cancel{8.3145\ J/mol\,K}\ 0.0821$
$\Delta n = 2 - (2+1)$
$= -1$
$K_p = K_c \cdot (RT)^{\Delta n}$

20) The equilibrium constant for reaction 1 is K. The equilibrium constant for reaction 2 is ____ _____. 20) E

(1) $SO_2\ (g) + (1/2)\ O_2\ (g) \rightleftharpoons SO_3\ (g)$
(2) $2SO_3\ (g) \rightleftharpoons 2SO_2\ (g) + O_2\ (g)$

A) $1/2K$ B) K^2 C) $-K^2$ D) $2K$ E) $1/K^2$

21) The reaction below is exothermic: 21) B

$$2SO_2\,(g) + O_2\,(g) \rightleftharpoons 2SO_3\,(g)$$

Le Châtelier's Principle predicts that _____ will result in an increase in the number of moles of SO_3 (g) in the reaction container.

A) removing some oxygen
B) increasing the pressure
C) increasing the volume of the container
D) decreasing the pressure
E) increasing the temperature

22) The equlibrium reaction $Co(H_2O)_6^{2+}$ (aq) (Pink) + 4 Cl^- (aq) <-> $CoCl_4^{2-}$ (aq) (Blue) + 6 H_2O(l) turns pink when placed in ice water mixture but turns blue in hot water. The reaction, as shown, is: 22) B

A) Nonthermic
B) Endothermic
C) Exothermic
D) Insufficient data

TRUE/FALSE. On the scantron, select answer 'A' if the statement is true and 'B' if the statement is false (3 pts each).

23) The value of the boiling- point- elevation constant (K_b) depends on the identity of the solvent. T or F

24) Adding a nonvolatile solute to a solution decreases the vapor pressure of the solution. T or F

25) The half- life for a first order rate law depends on the starting concentration. T or F

26) Units of the rate constant of a reaction are independent of the overall reaction order. T or F

27) At constant temperature, reducing the volume of a gaseous equilibrium mixture causes the reaction to shift in the direction that increases the number of moles of gas in the system. T or F

28) The effect of a catalyst on a chemical reaction is to react with product, effectively removing it and shifting the equilibrium to the right. T or F