Exam #1 **Name**_____

Minneapolis Community and Technical College
C1152 Fall 2023 ...Boraas

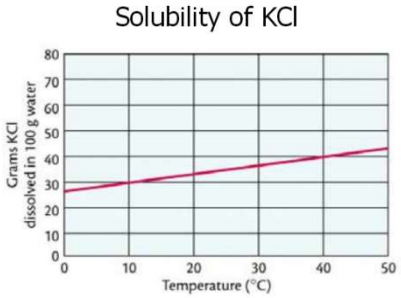
Directions:

- Write your name at the top of this exam.
- Record your answer to each multiple choice question in the space provided at left.
- You can write on this exam booklet. Additional scratch paper is available on request.
- Return this exam and all materials with your answer sheet. Failure to do so will result in a zero for the exam.
- You will have 3 hours to complete the exam. Sharing of calculators is not allowed.
- Bathroom trips are of course allowed. 1 person at a time.

1. _____ Choose the aqueous solution with the **lowest** freezing point temperature.

a. 1.3 *m* $C_6H_{12}O_6$ b. 1.3 *m* $Ca_3(PO_4)_2$ c. 1.3 *m* MgI_2 d. 1.3 *m* KCl e. 1.3 *m* $Al(NO_3)_3$

2. _____ 15.0 g of KCl is added to 100. g of water at 30°C and then thoroughly stirred with no additional special treatment.
Which of the following statements is correct?



a. … the solution is unsaturated and no solid precipitate is observed.

b. … the solution is saturated and solid precipitate is observed.

c. … the solution is saturated and no solid precipitate is observed

d. … the solution is unsaturated and solid precipitate is observed.

3. _____ Calculate the mass of oxygen (in mg) dissolved in a 5.00 L bucket of water exposed to a pressure of 1.13 atm of air.

Useful information: $\mathbf{X_{O2} = 0.21}$

$\mathbf{k_H = 1.3 \times 10^{-3}\ M/atm}$

a. 49.4 mg b. 23.5 mg c. 9.87 mg d. 27.3 mg e. 13.7 mg

4. _____ A solution is prepared by dissolving 98.6 g of NaCl in enough water to form an 875 mL solution. Calculate the NaCl mass % if the density of the solution is 1.06 g/mL.

a. 11.3% b. 10.6% c. 9.4% d. 12.7% e. 11.9%

5. _____ How many grams of NaOH are dissolved in 3.00 L of a 0.390 M solution?

a. 0.13 g_{NaOH} b. 1.17 g_{NaOH} c. 15.6 g_{NaOH}

d. 46.8 g_{NaOH} e. 110.54 g_{NaOH} f. 1.24 kg_{NaOH}

6. _____ How many milliliters of additional distilled water are required to dilute 500. mL of a 0.320 M acid solution to a concentration of 0.150 M?

a. 723 mL b. 85.6 mL c. 566 mL d. 643 mL e. 1070 mL

7._____ When calcium chloride is dissolved in distilled water, the temperature of the solution that forms increases. Which of the following is true?

a. ... the heat of hydration contributes **less** to solution formation than the lattice energy requirements
b. ... the heat of hydration contributes **more** to the solution formation than the lattice energy requirements
c. ... the heat of hydration contributes equally to solution formation and precipitation.
d. ... the heat of hydration is a positive value for this process.
e. ... the solution formation process is endothermic

8. _____ Which of the following statements is TRUE?

a. In general, the solubility of a solid in water decreases with increasing temperature.
b. In general, the solubility of a gas in water decreases with increasing temperature.
c. The solubility of a gas in water usually increases with decreasing pressure.
d. The solubility of an ionic solid in water decreases with increasing temperature.
e. None of the above statements are true.

9. _____ Which of the following is a **reasonable** Van't Hoff factor for a *very dilute* K_2SO_4 solution?

a. i = 1.50 b. i = 1.90 c. 2.30 d. 2.98 e. 3.08 f. 3.35

10. _____ As the concentration of a solution increases, which of the following is true?

a.	Vapor pressure increases	boiling point temperature decreases	freezing point temperature increases
b.	Vapor pressure increases,	boiling point temperature increases	freezing point temperature increases
c.	Vapor pressure decreases,	boiling point temperature decreases	freezing point temperature decreases
d.	Vapor pressure decreases,	boiling point temperature increases	freezing point temperature decreases
e.	Vapor pressure increases,	boiling point temperature increases	freezing point temperature decreases

11. _____ Consider the following chemical reaction:

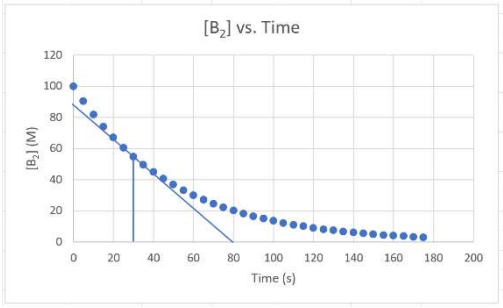
$$\mathbf{X_{(g)} + Y_{(g)} + Z_{(g)} \rightarrow 2M_{(g)} + 2N_{(g)}}$$

If the reaction is **second order in X** , **first order in Y**, and **third order *overall* ...**

..... by what factor does the rate of reaction increase if the concentrations of all reactants are doubled?

a. 2 × b. 4 × c. 6 × d. 8 × e. 12 × f. 24 ×

12. _____ The graph at right shows how the reactant B_2 concentration changes for the reaction below:



$$\mathbf{A_{2(g)} + 3\ B_{2(g)} \rightarrow 2\ C_{(g)}}$$

At what rate is the **product "C" being produced** at t = 30 seconds?
...closest answer please.

a. 1.12 M/s b. 1.69 M/s c. 0.75 M/s

d. 0.89 M/s e. 0.59 M/s f. 1.33 M/s

13. _____ Predict the rate law equation for the following **Type I** mechanism.

Overall: A + 2B + D → 2E

Mechanism

A + 2B	→	2C	*slow*
2C + D	→	2E	*fast*

a. Rate = k[A][B] b. Rate = $k[A][B]^2$ c. Rate = $k[C]^2[D]$

d. Rate = $k[A][B]^2[D]$ e. Rate = k [A] [B] $[D]^2$

14. _____Which of the following reactions would you expect to have the smallest collisional frequency factor "A"?

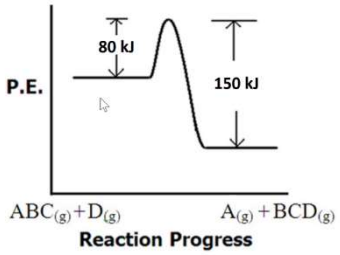
a. $A_{(g)} + B_{(g)} \rightarrow C_{(g)}$

b. $AB_{(g)} + C_{(g)} \rightarrow AC_{(g)} + B_{(g)}$

c. $AB_{(g)} + CD_{(g)} \rightarrow AC_{(g)} + BD_{(g)}$

d. $ABC_{(g)} + DFG_{(g)} \rightarrow ABD_{(g)} + CFG_{(g)}$

15. _____ Examine the reaction profile at right and determine ΔH_{rxn}.



a. +80 kJ/mol b.-80 kJ/mol c. +150 kJ/mol

d. -150 kJ/mol e.+70 kJ/mol f. -70 kJ/mol

16. _____ A reaction is found to have an activation energy of 108 kJ/mol.

If the rate constant for this reaction is $4.60 \times 10^{-6}\ s^{-1}$ at 275 K, what is the rate constant at 366 K?

a. $12\ s^{-1}$ b. $1.7\ s^{-1}$ c. $0.58\ s^{-1}$ d. $5.4 \times 10^{-5}\ s^{-1}$ e. $1.9 \times 10^{-4}\ s^{-1}$

17. _____ Which of the following will **not** increase the rate of a reaction?

a. Using a catalyst b. Proper mixing c. Increasing temperatures

d. Increasing reactant concentrations e. Increasing the reaction container's volume

18. _____ How will the equilibrium below shift if the total volume is increased?

$$2\ C_{2(g)} + AB_{2(l)} \leftrightarrow 2\ D_{2(g)}$$

a. The reaction shifts left with increases in volume

b. The reaction doesn't shift left or right with increases in volume

c. The reaction shifts right increases in volume.

19. _____ An equilibrium reaction takes place within a test tube.

When the test tube is placed in a hot water bath, the solution turns from Yellow to Blue.

$$2\ A + B \leftrightarrow C + D$$

Blue ***Yellow***

We conclude that the reaction is … a. exothermic b. endothermic c. isothermic d. superthermic

20. _____ Examine the following chemical equilibrium and initial concentrations:

	A	**+**	**2B**	**↔**	**C**	**+**	**D**	**$K_c = 1.99 \times 10^{-8}$**
initial	***0.00 M***		***2.00M***		***0.50M***		***0.30M***	

Which of the following statements is true?

a. The reaction shifts left and the x = 0 assumption is valid
b. The reaction shifts right and the x = 0 assumption is valid
c. The reaction shifts left and the x = 0 assumption is NOT valid
d. The reaction shifts right and the x = 0 assumption is NOT valid

21. _____ Express the equilibrium constant for the following reaction.

$$N_{2(g)} + 3\ H_{2(g)} \leftrightarrow 2\ NH_{3(g)}$$

a. $K = \dfrac{[N_2][H_2]^{1/3}}{[NH_3]^{1/2}}$ b. $K = \dfrac{[NH_3]^6}{[N_2]^3[H_2]^9}$ c. $K = \dfrac{[NH_3]^2}{[N_2][H_2]^3}$ d. $K = \dfrac{[N_2][H_2]^3}{[NH_3]^2}$ e. $K = \dfrac{[NH_3]^{1/2}}{[N_2][H_2]^{1/3}}$

22. _____ The equilibrium constant is given for one of the reactions below.
Determine the value of the missing equilibrium constant.

$2\ HD_{(g)} \rightleftharpoons H_{2(g)} + D_{2(g)}$ $\quad K_c = 0.28$

$2\ H_{2(g)} + 2\ D_{2(g)} \rightleftharpoons 4\ HD_{(g)}$ $\quad K_c = ?$

a. 7.8×10^{-2} b. 3.6 c. 0.53 d. 13 e. 1.9

23. _____ Determine the value of K_p for the following reaction if the equilibrium pressures are as follows:

$P(CO)_{eq} = 6.8 \times 10^{-11}$ atm $\quad P(O_2)_{eq} = 1.3 \times 10^{-3}$ atm $\quad P(CO_2)_{eq} = 0.041$ atm.

$$2\ CO_{(g)} + O_{2(g)} \rightleftharpoons 2\ CO_{2(g)}$$

a. $K_p = 3.6 \times 10^{-21}$ b. $K_p = 2.8 \times 10^{20}$ c. $K_p = 4.6 \times 10^{11}$
d. $K_p = 2.2 \times 10^{-12}$ e. $K_p = 3.6 \times 10^{-15}$

24. _____ Which of the following statements is TRUE?
a. If Q < K, it means the reverse reaction will proceed to form more reactants.
b. If Q > K, it means the forward reaction will proceed to form more products.
c. If Q = K, it means the reaction is at equilibrium.
d. All of the above are true.
e. None of the above are true.

25. _____ Which of the following is a STRONG base?
a. Cl^- b. NH_3 c. CH_3OH d. NO_3^- e. KOH

26. _____ Which of the following correctly demonstrates the $NaHCO_3$ *basic* equilibrium?

a. $HCO_3^-{}_{(aq)} + H^+{}_{(aq)} \leftrightarrow H_2CO_3^{-2}{}_{(aq)}$

b. $HCO_3^-{}_{(aq)} + H_2O_{(l)} \leftrightarrow CO_3^{-2}{}_{(aq)} + H_3O^+{}_{(aq)}$

c. $HCO_3^-{}_{(aq)} + H_2O_{(l)} \leftrightarrow H_2CO_3{}_{(aq)} + OH^-{}_{(aq)}$

d. $H_2CO_3{}_{(aq)} + OH^-{}_{(aq)} \leftrightarrow HCO_3^-{}_{(aq)} + H_2O_{(l)}$

e. $H_2CO_3{}_{(aq)} + H_2O_{(l)} \leftrightarrow HCO_3^-{}_{(aq)} + H_3O^+{}_{(aq)}$

27. _____ Consider the following equilibrium and identify the **strong base**.

$$\mathbf{CH_3COOH_{(aq)} + H_2O_{(l)} \longleftrightarrow H_3O^+_{(aq)} + CH_3COO^-_{(aq)} \quad K_a = 1.76 \times 10^{-5}}$$

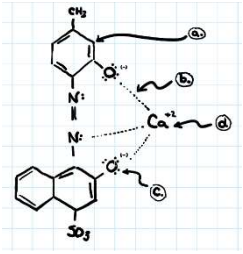
a. CH_3COOH b. H_2O c. H_3O^+ d. CH_3COO^-

28. _____ Calculate the molar concentration of H_3O^+ of a solution whose pOH = 4.33

a. 2.1×10^{-10} M b. 4.7×10^{-5} M c. 1.00×10^{-14} M d. 7.6×10^{-7} M

29. _____ Strong acids are rarely found in solution with their hydrogen ions still attached.
a. True b. False

31. _____ Referring to the diagram at right, what letter identifies the Lewis base?



*Show all work **neatly** for full credit. Answers must be circled, have correct significant figures and units.*

31. (5 pts) Initially, 0.500 mol_A , 0.500 mol_B and 1.00 mol_C are placed in an empty 6.50 liter container where the following equilibrium reaction takes place:

$$\mathbf{2\ A_{(g)} + 3\ B_{(g)} \leftrightarrow C_{(g)} \qquad K_c = 4.15 \times 10^{16}}$$

Determine the equilibrium concentrations of all species and check your work.

*Show all work **neatly** for full credit. Answers must be circled, have correct significant figures and units.*

32. (5 pts) The rate constant for the ***first order*** reaction $2NO_2 \rightarrow N_2O_4$ is 2.79 min^{-1} at 48°C.

If the initial concentration of NO_2 is 9.80 M, determine the following:

a. The reaction's half-life in minutes.

b. The time in minutes required for the NO_2 concentration to reach 0.120 M

c. The time in minutes required for 90% of the NO_2 to have decomposed.

*Show all work **neatly** for full credit. Answers must be circled, have correct significant figures and units.*

33. (5 pts) Examine the following weak acid ICE table and determine the following six quantities:

a. pH

b. $[HA]_{eq}$

c. K_a for the weak acid

d. K_b for the conjugate base

e. % ionization

	$HA_{(aq)}$	+	$H_2O_{(l)}$	↔	$H_3O^+_{(aq)}$	+	$A^-_{(aq)}$
I	**0.100 M**		**~**		**0 M**		**0 M**
C	_____				_____		_____
E	_____				**1.056×10^{-5}**		_____

*Show all work **neatly** for full credit. Answers must be circled, have correct significant figures and units.*

34. (5 pts) A solution made by dissolving 7.25 g of a nonvolatile, molecular solid in 120.0 mL of distilled water. The solution is found to experimentally freeze at -4.89 °C at 760 mm Hg.

Useful Information: Water: $K_f = 1.86$ °C/m $K_b = 0.512$ °C/m D = 1.00 g/mL

a. What is the approximate molecular weight of the substance?

b. What is the boiling point temperature of the solution?

35. (Bonus 1pt) What is required for a molecular collision to be "effective?"

36. (Bonus 1 pt) Give an example of a multi-step process in your life. **(List steps)**

Clearly identify the rate limiting step and explain in detail what makes it rate limiting.

38. (Bonus 1 pt) Explain why the following equilibrium problem requires a material shift:

	$N_{2(g)}$	+	$O_{2(g)}$	↔	**2 $NO_{(g)}$**	**$K_c = 6.00 \times 10^{-31}$**
Initial	2.00 M		2.00 M		0.500 M	