EXAM III
CHEM 1A
Part I (Multiple Choice, 69 points) Name Key

For the following questions choose the best answer. (3 points each)

1) Hydrogen bonding exists between molecules of which of the following substances?

I. CH_3OCH_3 II. CH_3NH_2 III. CH_3OH IV. CH_3PH_2

A. I only
B. II only
C. III only
D. IV only
E. II and III

2) Under which of the following conditions does a gas behave most like an ideal gas?

A. STP
B. 2.00 atm and 273 K
C. 3.00 Pa and 100 ^{0}C
D. 1.00 torr and 100 ^{0}C
E. 2.00 torr and 300 K

high temp & low pressure cause potential energy due to intermolecular forces to become less significant allowing for more ideal behavior

3) Which of the following indicates the presence of **weak intermolecular forces** in a liquid?

A. a high heat of vaporization
B. a high critical temperature
C. a low vapor pressure
D. a low viscosity
E. a high surface tension

4) Which of the following liquids has the **lowest boiling point** temperature?

A. F_2 B. HF C. N_2 D. CH_4 E. H_2

5) Which of the following solids has the **highest melting point** temperature?

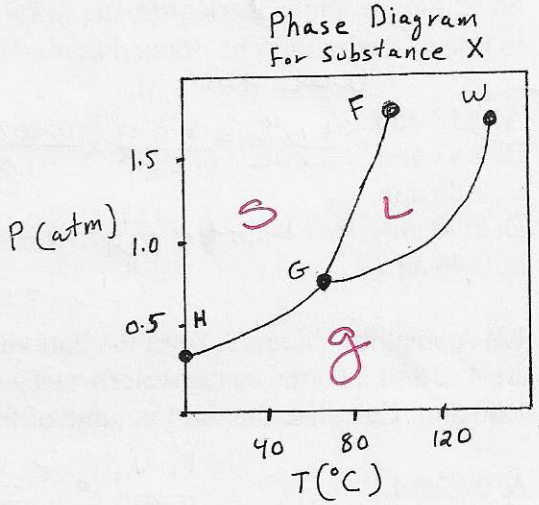
A. $\overset{+}{K}\overset{-}{Cl}$ B. SiC C. $\overset{+}{Na}\overset{-}{F}$ D. Sucrose ($C_{12}H_{22}O_{11}$) E. Br_2

The largest charge & the smaller the atomic radius will yield the strongest bonds.

For questions 6-8 use the following figure:

6) What will happen to substance X if it begins at 1.0 atm and 40^{0}C and the temperature is increased to 80 ^{0}C under constant pressure?

A) It will stay the same
B) It will melt
C) It will sublimate
D) It will vaporize
E) It will condense



7) What is the boiling point of substance X at 1.00 atm?

A. 78 ^{0}C
B. 118 ^{0}C
C. 40^{0}C
D. It sublimates at that pressure
E. Under 1.00 atm, it remains a solid at any temperature

8) All three states of substance X coexist (are at equilibrium) at/along

A. H-G curve
B. G-F curve
C. G-W curve
D. point H
E. point G

9) Which of the following gases would have the highest critical temperature?

A. NH_3
B. O_2
C. CO_2
D. CH_4
E. Ne

the polar molecule that can hydrogen bond

10) Which of the following substances will be most soluble in cyclohexane (C_6H_{12})?

The one w/ no hydrogen bonds

A. I_2
B. H_2O
C. NaOH
D. NH_3
E. HF

11) Bubbles of oxygen gas from photosynthesis form on the leaves of an underwater plant at a depth of 140. ft. If the plant is growing near the coast of New Jersey on a day on which the atmospheric pressure is 760. mmHg, what is the pressure of the oxygen gas in one of the bubbles mentioned above? (1 in = 2.54 cm)

use psi

A. 5.13 atm
B. 4.82 atm
C. 3.86 atm
D. 2.90 atm
E. 0.96 atm

$\frac{1.09\ g}{mL} = \frac{1.09\ g}{cm^3} \times \frac{0.002211\ lbs}{1\ g} \times \left(\frac{2.54\ cm}{in}\right)^3 = 0.036127 \frac{lbs}{in^3}$

$140\ ft \times \frac{12\ in}{1\ ft} \times \frac{0.036127\ lbs}{in^3} = 60.69 \frac{lbs}{in^2} \times \frac{1\ atm}{14.7\ psi}$

$= 4.13 + (760\ mm\ Hg \times \frac{1\ atm}{760\ atm}) = 5.13\ atm$

12) A small bubble rises from the bottom of a lake, where the temperature and pressure are 4^0C and 2.0 atm, to the water's surface, where the temperature is 25^0C and pressure is 1.00 atm. Calculate the final volume of the bubble if its initial volume was 2.0 mL.

$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

A. 0.72 mL
B. 1.4 mL
C. 1.5 mL
D. 3.0 mL
E. 4.3 mL

13) How many liters of chlorine gas at 1.00 atm and 273 K can be produced by the reaction of 86.9 g of MnO_2 with 0.200 L of 2.50 M HCl solution?

$MnO_2(s) + 4HCl(aq) \rightarrow MnCl_2(aq) + 2H_2O(l) + Cl_2(g)$

A. 1.56 L
B. 0.567 L
C. 3.57 L
D. 2.80 L
E. 22.4 L

$86.9\ g\ MnO_2 \times \frac{1\ mol\ MnO_2}{86.94\ g} \times \frac{1\ mol\ Cl_2}{1\ mol\ MnO_2} = 0.99953\ mol\ Cl_2$

$0.200\ L \times \frac{2.50\ mol\ HCl}{1\ L} \times \frac{1\ mol\ Cl_2}{4\ mol\ HCl} = 0.125\ mol\ Cl_2$ LR

$PV = nRT \qquad V = \frac{(0.125\ mol)(0.0821 \frac{L \cdot atm}{mol \cdot K})(273\ K)}{1.00\ atm}$

14) How many grams of carbon dioxide gas is dissolved in a 1.00 L bottle of carbonated water if the manufacturer uses a pressure of 2.4 atm in the bottling process at 25 °C? Given: K_H of CO_2 in water = 0.0301 M/atm at 25 °C.

$\Delta S = k_H P_{gas}$

A. 3.52 g
B. 3.18 g
C. 5.55 g
D. 4.67 g
E. 0.0755 g

$\frac{0.0301\ M}{atm} \times \frac{2.4\ atm}{1} = 0.07224 \frac{mol}{L}$

$1.00\ L \times \frac{0.07224\ mol}{1\ L} \times \frac{44.01\ g\ CO_2}{1\ mol} =$

15) Which of the following (or combination of the following) will result in **decrease** of equilibrium vapor pressure of water in a closed container?

I. Decreasing the amount of liquid water no impact
II. Increasing the temperature phase change
III. Dissolving sugar in water yes colligative property ✓
IV. Decreasing the temperature slowing KE. ✓

A. I and II
B. I and III
C. III only
D. III and IV
E. None of the above

16) In how many grams of water should 25.3 g of sodium chloride (NaCl) be dissolved to prepare a 0.0991 m solution?

A. 4.36×10^3 g
B. 792 g
C. 3.96 g
D. 500. g
E. 7,917 g

$m = \frac{\text{mol solute}}{\text{kg solvent}}$

$0.0991\ m = \frac{25.3\text{g NaCl} \times \frac{1\text{ mol NaCl}}{58.45\text{g}}}{x}$

17) Calculate the molality of 6.0 M H_2SO_4 solution. The density of the solution is 1.34 g/mL.

assume 1L

A. 10.2 m
B. 4.48 m
C. 7.98 m
D. 8.10 m
E. 8.43 m

$\frac{1\text{ L soln}}{} \times \frac{1000\text{ml}}{1\text{L}} \times \frac{1.34\text{g}}{1\text{ml}} = 1340\text{g soln}$

$6.0\text{mol } H_2SO_4 \times \frac{98.078\text{g}}{1\text{mol}} = 588.468\text{g } H_2SO_4$

$1340\text{g soln} - 588.468\text{g solute} = 751.532\text{g solvent} = 0.751532\text{kg solvent}$

$\frac{6.0\text{ mol}}{}$

18) If equal masses of $O_2(g)$ and HBr(g) are in separate containers of equal volume and temperature, which one of the following statements is true?

A. The pressure in the O_2 container is greater than that in the HBr container.
B. There are more HBr molecules than O_2 molecules.
C. The average kinetic energy of O_2 molecules is greater than that of HBr molecules.
D. The average kinetic energy of HBr molecules is greater than that of O_2 molecules.
E. The pressures of both gases are the same.

19) A mixture of two gases contains 10.0 g of hydrogen gas and 10.0 g of neon gas and has a total pressure of 2.0 atm. Calculate the partial pressure of hydrogen gas in that mixture.

$10.0\,g\,H_2 \times \frac{1\,mol\,H_2}{2.02\,g} = 4.95\,mol\,H_2$

$10.0\,g\,Ne \times \frac{1\,mol\,Ne}{20.18\,g} = 0.495\,mol\,Ne$

$\chi_{H_2} = \frac{4.95\,mol}{5.4455\,mol} = 0.909$

$(0.909)(2.0\,atm) \times \frac{760\,mmHg}{1\,atm} = 1.381 \times 10^3\,mmHg$

A. 1.4×10^3 mmHg
B. 7.6×10^2 mmHg
C. 6.8×10^2 mmHg
D. 1.5×10^3 mmHg
E. 1.8×10^3 mmHg

20) The following gases are at 25°C: N_2, Ne, Ar, O_2, Cl_2

The molecules in which gas have the highest average kinetic energy (KE), and the molecules in which have the highest molecular speed (MS)?

A. N_2 has the highest average KE and the highest average MS
B. Ne has the highest average KE and the highest average MS
C. They all have the same average KE and Ne has the highest average MS
D. Cl_2 has the highest average KE and they all have the same average MS
E. They all have the same average KE and average MS

21) 10.0g of glucose ($C_6H_{12}O_6$; MW 180; a nonvolatile, nonelectrolyte solute) and 10.0g of water are mixed together. When this solution is warmed to 60. °C, the sugar dissolves in water. What is the vapor pressure of this solution at 100.°C? → all H_2O is gas ∴ 1 atm

$P = \chi_{solvent} \cdot P_{solvent}$

$10.0\,g\,sucrose \times \frac{1\,mol}{180\,g} = 0.0556\,mol\,sucrose$

$10.0\,g\,H_2O \times \frac{1\,mol}{18.02\,g} = 0.5549\,mol\,H_2O$

$\chi_{solvent} = \frac{0.5549\,mol}{0.6105\,mol} =$

$(0.908867)(1\,atm)\left(\frac{760\,mmHg}{1\,atm}\right) = 690.739\,mmHg$

A. 745 torr
B. 760 torr
C. 68.4 torr
D. 691 torr

22) In an effusion experiment it required 43.6 seconds for 1.0 L of an unknown gas to pass through a small hole in a vacuum. Under the same conditions, 10.0 seconds were required for 1.0 L of hydrogen gas to effuse. Which of the following is the unknown gas?

$\frac{rate\,A}{rate\,B} = \sqrt{\frac{M_B}{M_A}}$ $\left(\frac{43.6\,sec/L}{10.0\,sec/L}\right)^2 = \frac{M_B}{2.02\,g/mol}$

$H_2 = A$
$? = B$
M = molar mass

$M_B = 38.0192\,g/mol$

A. F_2
B. O_2
C. CH_4
D. Ne
E. Cl_2

23) Arrange the following aqueous solutions in terms of increasing freezing point temperature.(Lowest→Highest)

2.0 m NaCl, 2.0 m Sucrose($C_{12}H_{22}O_{11}$), 2.0 m Na_3PO_4, 2.0 m $H_2C_2O_4$,

A. 2.0 m NaCl, 2.0 m $H_2C_2O_4$, 2.0 m Sucrose, 2.0 m Na_3PO_4
B. 2.0 m Na_3PO_4, 2.0 m NaCl, 2.0 m $H_2C_2O_4$, 2.0 m Sucrose
C. 2.0 m Sucrose, 2.0 m $H_2C_2O_4$, 2.0 m NaCl, 2.0 m Na_3PO_4
D. 2.0 m Na_3PO_4, 2.0 m NaCl, 2.0 m Sucrose, 2.0 m $H_2C_2O_4$
E. None of the above

NaCl: $\frac{2.0\ mol}{kg\ solvent} \times \frac{1\ mol\ NaCl}{58.44\ g} \times 2 = 0.06849$ (4)

Sucrose: $\frac{2.0\ mol}{kg\ solvent} \times \frac{1\ mol\ Sucrose}{342.296\ g} \times 1 = 0.00584$ (1)

Na_3PO_4: $2\ m \times \frac{1\ mol\ Na_3PO_4}{163.941\ g} \times 4 = 0.0487$ (2)

$H_2C_2O_4$: $2\ m \times \frac{1\ mol\ H_2C_2O_4}{90.04\ g} \times 3 = 0.06664$ (3)

Part II (31 points)
For the following 3 questions you must show work and round off your answer to the correct number of significant figures for full credit. Place your final answer inside the provided box.

24) Adrenaline is the hormone that triggers the release of extra glucose in times of stress. A solution of 0.64g of adrenaline in 36.0g of CCl_4 increases the normal boiling point of CCl_4 to 77.29 ^{0}C. The normal boiling point of pure CCl_4 is 76.80 ^{0}C. Calculate the molar mass of adrenaline. (K_b for CCl_4 is 5.02 ^{0}C/m, and K_f for CCl_4 is 29.8 ^{0}C/m) (6 points)

$\Delta T = m \cdot K_b \qquad m = \frac{\Delta T}{K_b}$

$m = \frac{77.29^\circ C - 76.80^\circ C}{5.02^\circ C/m} = 0.0976\ m$

$m = \frac{\text{mole Solute}}{\text{kg solvent}} \qquad \frac{\text{moles adrenaline ("A")}}{0.0360\ kg\ CHCl_3} = 0.0976$

$\text{mole A} = 0.003516$

$A_{Mass}: \frac{0.64g}{0.003516\ mol} = 182.025028$

$1.8 \times 10^2\ g/mol$

$1.8 \times 10^2\ g/mol$

25) Write the balanced molecular, total ionic, and net ionic equations for the following reactions. (5 points each)

a) $BaCl_2\,(aq) + Na_2SO_4(aq) \rightarrow$ $BaSO_4(s) + 2NaCl(aq)$

$Ba^{+2} + 2Cl^- + 2Na^+ + SO_4^{-2} \rightarrow BaSO_4(s) + 2Na^+ + 2Cl^-$

$Ba^{+2} + SO_4^{-2} \rightarrow BaSO_4(s)$

b) $HCl(aq) + KC_2H_3O_2(aq) \rightarrow$ weak acid $HC_2H_3O_2(aq) + KCl(aq)$

$H^+ + Cl^- + K^+ + C_2H_3O_2^- \rightarrow HC_2H_3O_2(aq) + K^+ + Cl^-$

since weak acid do not completely dissociate

$H^+ + C_2H_3O_2^- \rightarrow HC_2H_3O_2$

26) What is the concentration of phosphate ions at the end of the reaction of 45.0 mL of 0.300 M $CaCl_2$ with 25.0 mL of 1.00 M Na_3PO_4?(assume the volumes add)(8 points)

$$3CaCl_2(aq) + 2Na_3PO_4(aq) \longrightarrow Ca_3(PO_4)_2(s) + 6NaCl(aq)$$

$$3Ca^{+2} + 6Cl^- + 6Na^+ + 2PO_4^{-3} \longrightarrow Ca_3(PO_4)_2(s) + 6Na^+ + 6Cl^-$$

$$3Ca^{+2} + 2PO_4^{-3} \longrightarrow Ca_3(PO_4)_2(s)$$

	Ca^{+2}	PO_4^{-3}	Na^+	Cl^-	$Ca_3(PO_4)_2$
mmol	13.5	25	75	27	∅
Δ	13.5	9	0	0	4.5
Final	0	16	75	27	4.5
M	0	$\frac{0.016\,mol}{0.07\,L}$	1.07M	0.386M	N/A

$$0.045L \times \frac{0.300\,mol\,CaCl_2}{1L} \times \frac{1\,mol\,Ca^{+2}}{1\,mol\,CaCl_2} = 0.0135 \text{ or } 13.5\,mmol$$

$$\times \frac{2\,mol\,Cl^-}{1\,mol\,CaCl_2} = 27\,mmol$$

$$0.025L \times \frac{1.00\,mol\,Na_3(PO_4)}{1L} \times \frac{3\,mol\,Na^+}{1\,mol\,Na_3PO_4} = 75\,mmol$$

$$\times \frac{1\,mol\,PO_4^{3-}}{1\,mol\,Na_3PO_4} = 25\,mmol$$

$$0.0135\,mol\,Ca^{+2} \times \frac{2\,mol\,PO_4^{-3}}{3\,mol\,Ca^{+2}} = 9\,mmol\,PO_4^{-3}$$

Total vol: 0.07L

$$\frac{0.016\,mol\,PO_4^{3-}}{0.07L} = 0.22857M\,PO_4^{-3}$$

alternative

$CaCl_2$ = L-R

$$0.045L \times \frac{0.300\,mol\,CaCl_2}{1L} \times \frac{1\,mol\,Ca_3(PO_4)_2}{3\,mol\,CaCl_2} = 0.0045\,mol\,Ca_3(PO_4)_2$$

$$0.025L \times \frac{1.00\,mol\,Na_3PO_4}{1L} \times \frac{1\,mol\,Ca_3(PO_4)_2}{2\,mol\,Na_3PO_4} = 0.0125\,mol\,Ca_3(PO_4)_2$$

$$(0.0125\,mol - 0.0045\,mol)\,Ca_3(PO_4)_2 \times \frac{2\,mol\,Na_3PO_4}{1\,mol\,Ca_3(PO_4)_2} \times \frac{1\,mol\,PO_4^{-3}}{1\,mol\,Na_3PO_4} = 0.016\,mol\,PO_4^{-3}$$

$$\frac{0.016\,mol\,PO_4^{3-}}{0.07L} = 0.22857M\,PO_4^{-3}$$

0.229 M PO_4^{-3}

27) A gaseous compound is 30.4% nitrogen and 69.6% oxygen by mass. A 5.25-g sample of the gas occupies a volume of 1.00 L and exerts a pressure of 1.26 atm at -4.0^{0}C. Determine the molecular formula of that gas. (7 points)

$PV = nRT$

$n = \frac{PV}{RT} = \frac{(1.26\ atm)(1.00\ L)}{(0.0821 \frac{L \cdot atm}{mol \cdot K})(269\ K)}$

$= 0.0570\bar{5}2\ mol$

$Mwt = \frac{5.25\ g}{0.0570\bar{5}2\ mol} = 92.\bar{0}213\ g/mol$

Empirical Formula

$30.4\ g\ N \times \frac{1\ mol\ N}{14.01\ g} = 2.1698\ mol\ N$

$69.6\ g\ O \times \frac{1\ mol\ O}{16.00\ g} = 4.35\ mol$

$N_{\frac{2.1698}{2.1698}}\ O_{\frac{4.35}{2.1698}}$

NO_2

Mwt: 46.01

$\frac{92.0213\ g/mol}{46.01\ g/mol} = 2$

Molecular formula: $2(NO_2)$

N_2O_4

N_2O_4