Time : 60 minutes	Chemistry 201 Quiz 2	May 15, 2007 *R. Sultan*

Name : KEY ____________________ **Signature :** ____________________

Student Number : ____________________

Circle your *recitation* **Section :**

Sect. 1	12 F	(Prof. Sultan)
Sect. 2	8 Th	(Prof. El-Rassy)
Sect. 3	12:30 Th	(Prof. El-Rassy)

Useful Information

Gas constant $R = 0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1}$
$= 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$

Conversion: $1.00 \text{ atm} = 1.013 \times 10^5 \text{ Pa}$

There are 20 questions. In each question, only ONE of the proposed answers is right. Circle the letter corresponding to the right answer.

Good luck

- Which of the following statements about a Van der Waals' gas is <u>false</u>?

✓ a. If we neglect intermolecular forces and consider only the volume of the gas molecules, the pressure appears greater than the value predicted by the ideal gas equation.

✓ b. At high temperature, a gas approaches ideal behavior because the gas particles move so rapidly that the effect of inter-particle attractions is not very important.

✓ c. The Van der Waals constant *b* is a measure of the volume occupied by one mole of gas molecules when the latter are brought in close contact with each other.

✗ (d.) The Van der Waals constant *a* is higher for CH_4 than for CO_2. CO bond more polar than CH → London forces are stronger.

✓ e. When we correct for both the intermolecular forces *and* the molecular volume factors, the corrected volume and the corrected pressure satisfy the ideal gas equation.

- The viscosity of a liquid may roughly be defined as its resistance to flow. From the viewpoint of intermolecular forces, which of the following is the correct order of **decreasing** viscosity for the listed liquids? Strong attractions ⇔ high viscosity

a. $CH_3OH > H_2O > CH_3—C(=O)—CH_3 > CH_3CH_2—O—CH_2CH_3$

(b.) $H_2O > CH_3OH > CH_3—C(=O)—CH_3 > CH_3CH_2—O—CH_2CH_3$

c. $CH_3OH > H_2O > CH_3—C(=O)—CH_3 > CH_3CH_2—O—CH_2CH_3$

d. $H_2O > CH_3—C(=O)—CH_3 > CH_3OH > CH_3CH_2—O—CH_2CH_3$

e. $H_2O > CH_3OH > CH_3CH_2—O—CH_2CH_3 > CH_3—C(=O)—CH_3$

- A chemist prepares 0.100 mol of Ne(g) at a certain temperature and pressure in an expandable container. Another 0.010 mol of neon atoms is then added to the same container. How must the volume be changed in order to keep the pressure and the temperature the same?

P, T constant

a. The volume must increase by a factor of 10.
b. The volume must decrease by a factor of 10.
(c.) The volume must increase by a factor of 1.1.
d. The volume must not change.
e. At least either the temperature or the pressure must change.

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

$$\longrightarrow n_1 V_2 = V_1 n_2$$

$$\frac{V_2}{V_1} = \frac{n_2}{n_1} = \frac{0.110}{0.100} = \boxed{1.1}$$

each other 207.3

- Xenon and fluorine react with ~~react~~ at 350°C to produce XeF_4 according to the reaction:

$$Xe\,(g) \quad + \quad 2\,F_2\,(g) \longrightarrow \quad XeF_4\,(g)$$

1.97 atm 623 K

What volumes of xenon and fluorine at 200 kPa and 350°C are needed to produce 1.00 mg of XeF_4, assuming a 100% yield in the reaction?

a. $v_{Xe} = 6.92 \times 10^{-4}$ mL; $v_{F2} = 1.38 \times 10^{-3}$ mL.
b. $v_{Xe} = 1.23 \times 10^{-3}$ mL; $v_{F2} = 2.46 \times 10^{-3}$ mL.
✓ⓒ $v_{Xe} = 0.125$ mL; $v_{F2} = 0.250$ mL.
d. $v_{Xe} = 7.03 \times 10^{-2}$ mL; $v_{F2} = 0.141$ mL.
e. None of the above.

$n_{XeF_4} = \frac{1.00 \times 10^{-3}}{207.3} = 4.82 \times 10^{-6}$ mol

$R = 0.08206$

$n_{Xe} = 4.82 \times 10^{-6}$ mol

$n_{F_2} = 2n_{XeF_4} = 9.64 \times 10^{-6}$ mol

$PV = nRT \Rightarrow V_{Xe} = \frac{n_{Xe}RT}{P} = 1.25 \times 10^{-4}$ L $= 0.125$ mL

Similarly: $V_{F_2} = 2 \times V_{Xe} = 0.250$ mL

- Which of the following statements is true?

✗ a. The ratio of the rate of effusion of 2.00 moles of Ar gas to the rate of effusion of 3.00 moles of Ne gas (measured in the same effusion apparatus and at the same temperature) is 0.711.
✗ b. At the same temperature, more gas molecules travel at the u_{rms} speed than at u_{mp}. more (at the maximum)
✗ c. At the same temperature, all the molecules possess the same kinetic energy. → average K.E ✓
✓ⓓ The kinetic molecular theory of gases predicts successfully the distribution of molecular speeds measured experimentally using a velocity selector.
✗ e. In a 1.00 meter long tube with a cotton wetted with HCl solution at one end, and another cotton wetted with NH_3 solution at the other end, the NH_4Cl ring forms nearly at 33 cm from the HCl end, and not exactly so because of gas collisions.
f. d) and e) No
g. c) and d). No

ⓐ. $\frac{R_{Ar}}{R_{Ne}} = \frac{2.00}{3.00}\sqrt{\frac{20.18}{39.95}} = 0.474$

ⓔ $\frac{R_{NH_3}}{R_{HCl}} = \frac{\bar{u}_{NH_3}}{\bar{u}_{HCl}} = \sqrt{\frac{36.45}{17.03}} = 1.46$

- Which of the following statements is true?

✓ⓐ In the phase diagram of a pure substance, the solid-vapor equilibrium line is always steeper than the liquid-vapor equilibrium line.
✗ b. The boiling of a liquid is favored both enthalpy wise and entropy wise.
✗ c. ΔH_{vap} of a liquid can be determined from the linear plot of P versus $1/T$. ln P vs 1/T
✗ d. Liquid-vapor equilibrium can be reached when the liquid is placed in an open container. Container must be closed!
✗ e. If the pressure of the air above a certain liquid is decreased, then the liquid will boil at a higher temperature.

ⓔ cont'd $R_{NH_3} + R_{HCl} = 100 \Rightarrow R_{HCl} \times 1.46 + R_{HCl} = 100 \;|\; R_{HCl} = \frac{100}{2.46} = 40.7$ cm

• Consider the solids X, Y and Z with the following properties:

Substance	Appearance	Melting point (°C)	Electrical conductivity	Solubility in water
X	hard, colorless	146	none	soluble
Y	very hard, colorless	1600	none	insoluble
Z	hard, orange	398	Only if melted or dissolved in water	soluble

What information about the type of solid for each substance can be inferred from the above data?

a. X metallic; Y network; Z ionic.
b. X molecular; Y ionic; Z metallic
c. X ionic; Y network; Z molecular.
(d.) X molecular; Y network; Z ionic.
e. X network; Y metallic; Z ionic.

• Experiments show that the vapor pressure of benzene is 75 Torr at 20°C. Given that ΔH_{vap} of benzene is 30.8 kJ/mol, the predicted normal boiling point of benzene is:

a. 359 °C
b. 218 °C
c. 76.9 °C
(d) 86 °C
e. 80 °C

$\begin{cases} P_1 = 75 \text{ Torr} \\ T_1 = 293 \text{ K} \end{cases}$ $\begin{cases} P_2 = 760 \text{ Torr} \\ T_2 = T_b = ? \end{cases}$

Clausius-Clapeyron → $\ln \frac{P_2}{P_1} = \frac{\Delta H_{vap}}{R} \cdot \left(\frac{1}{T_1} - \frac{1}{T_2}\right)$ ⇒ $6.253 \times 10^{-4} = 3.413 \times 10^{-3} - \frac{1}{T_2}$

2.316 3,704 3.413×10^{-3}

$\frac{1}{T_2} = 2.788 \times 10^{-3}$

$T_2 = 359$ K

$t_2 = 86°C$

• A 1.37 M solution of citric acid ($H_3C_6H_5O_7$) in water has a density of 1.10 g/cm^3. What is the mass percent of this solution?

a. 11.0%
b. 7.84%
(c.) 23.9%
d. 38.0%
e. 18.4%

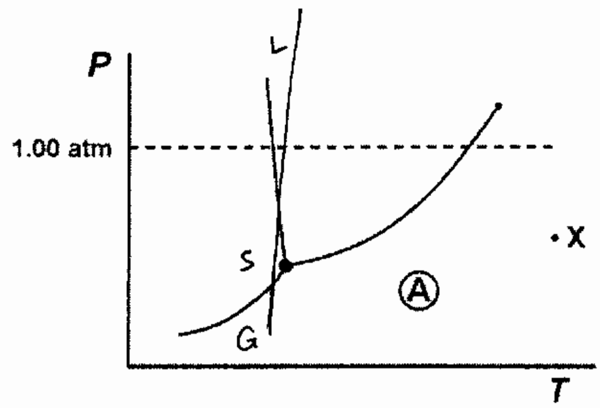
$M_0 = \frac{n_{citric}}{V_{soln}} = \frac{m_{citric}}{M_{citric} V_{soln}}$

mass percent → $= \frac{\rho \times m_{soln}}{M_{citric} \times V_{soln}}$, $\frac{m_{soln}}{V_{soln}} = d$ $= \frac{\rho d}{M_{citric}}$

$\rho = \frac{M_0 \times M_{citric}}{d} = \frac{1.37 \text{ (mol/L)} \times 192 \text{ (g/mol)}}{1.10 \times 10^3 \text{ (g/L)}}$

$= 0.239$ → $m\% = \rho \times 100$
$= 23.9\%$

• Consider the phase diagram shown below:



Which of the following statements is false? slope of (-ve / S/L boundary)

✓ a. The solid has a larger molar volume than the liquid. like water

✓ b. At some (constant) temperature, the gaseous substance can be compressed into a solid then into a liquid in this order.

✓ c. When phase A is compressed at constant temperature at point X, no change is observed. $T > T_{critical}$

✓ d. When heated at 1.0 atm, the solid substance will first melt then boil.

yes (e) None of the above statements is false.

• What is the osmotic pressure of a 0.500 M solution of $Ca(NO_3)_2$ in water at 298 K, assuming that the salt is 85.0% dissociated? $Ca^{2+} + 2NO_3^- \longrightarrow$ 3 particles $\times 0.850$

a. 36.7 atm

b. 12.2 atm

c. 24.5 atm

(d) 31.2 atm

e. 10.4 atm

$\pi = i M_0 R T$

$= 0.850 \times 0.500 \times 0.08206 \times 298 \times 3$

$= 31.2$ atm

• Which of the following properties of liquids suggest that they resemble *more solids* than gases? Circle the best answer.

✗ a. Fluidity

✗ b. The Brownian motion in liquids

✓ c. ΔH_{vap} of a subastance >> ΔH_{fus} → much closer to solid (small ΔH_{fus})

✓ d. In most substances, the volume of a liquid decreases by about 4% upon freezing.

e. a) and b) No

(f.) c) and d)

g. a) and d) No

- Which of the following expressions derived from the **K**inetic **M**olecular **T**heory for ideal gases is correct?

  ✗ a. Energy of one (mole) of structureless gas particles = $\frac{3}{2}kT$, where k is Boltzmann's constant. $\frac{3}{2}RT$

  ✓ (b.) $nRT = \frac{2}{3}N\varepsilon$, where ε is the average kinetic energy of a gas particle, $N \equiv$ total number of molecules, $n \equiv$ number of moles. $pV = \frac{1}{3}Nm\overline{u^2} = \frac{1}{3}N \times 2 \times \left(\frac{1}{2}m\overline{u^2}\right)\varepsilon = nRT = \frac{2}{3}N\varepsilon$

  ✗ c. $\frac{1}{2}m\bar{u}^2 = \frac{3}{2}\frac{R}{N_A}T$, where u denotes the speed of a gas particle. $\frac{1}{2}m\overline{u^2}$ not $\bar{u}^2$ ✗

  ✗ d. $u_{mp} > u_{rms} > \bar{u}$ No $u_{rms} > \bar{u} > u_{mp}$

  e. The fraction of gas molecules traveling at a certain speed u is highest at u_{rms}. No at u_{mp} hence its name: most probable speed.

- Which of the following is true about the process of dissolution?

  ✓ a. ΔH for the expansion of the solvent is never negative.

  ✓ b. ΔH for the expansion of the solute is never negative.

  ✓ c. ΔH for the mixing of solvent and solute can be either positive or negative.

  ✓ d. ΔS for the mixing of solvent and solute is always positive.

  (e.) All the above.

- Which of the following is a criterion of spontaneity for a given process?

  ✗ a. $\Delta S_{sys} > 0$

  ✓ b. $\Delta S_{univ} > 0$

  ✗ c. $\Delta G_{univ} < 0$

  ✓ d. $\Delta G_{sys} < 0$

  ✓ e. $-\Delta G_{sys}/T > 0$

  ✗ f. b) and d)

  (g.) b) d) and e)

  ✗ h. a) d) and e)

  $\Delta S_{univ.} = \Delta S_{sys} + \Delta S_{surr.} = \Delta S_{sys} - \frac{\Delta H_{sys.}}{T}$

  For system: $\Delta G = \Delta H - T\Delta S$

  $-\frac{\Delta G}{T} = -\frac{\Delta H}{T} + \Delta S$

  $\Rightarrow \Delta S_{univ.} = -\frac{\Delta G_{sys.}}{T}$

- A small bubble rises from the bottom of a lake, where the temperature and pressure are 4°C and 3.0 atm, to the water's surface, where the temperature is 25°C and pressure is 0.95 atm. Calculate the final volume of the bubble if its initial volume was 2.1 mL.

  a. 0.72 mL

  b. 6.2 mL

  (c.) 7.1 mL

  d. 22.4 mL

  e. 41.4 mL

  $T_1 = 277$ K, $P_1 = 3.0$ atm., $V_1 = 2.1$ mL

  $T_2 = 298$ K, $P_2 = 0.95$, $V_2 =$??

  n const $\rightarrow \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \Rightarrow V_2 = V_1 \times \frac{T_2}{T_1} \times \frac{P_1}{P_2}$

  $= 2.1 \times \frac{298}{277} \times \frac{3.0}{0.95} = 7.1$

- Arrange the following aqueous solutions in order of increasing boiling points: 0.050 m $Mg(NO_3)_2$; 0.100 *m* ethanol; 0.090 *m* NaCl. Calculate $i\,m_o$

  0.15 0.100 0.18

  a. $Mg(NO_3)_2$ < NaCl < ethanol
  (b) ethanol < $Mg(NO_3)_2$ < NaCl
  c. ethanol < NaCl < $Mg(NO_3)_2$
  d. NaCl < ethanol < $Mg(NO_3)_2$
  e. $Mg(NO_3)_2$ < ethanol < NaCl

- Pentane and Hexane are two liquids that form an ideal solution. The vapor pressure of pure pentane is 511 torr, and that of hexane is 150 torr at 25°C. In a plot of vapor pressure versus mole fraction of pentane $\chi_{pentane}$, the lines of $P_{pentane}$ and P_{hexane} intersect at $\chi_{pentane}$ equal to:

  a. 0.500
  b. 0.416
  c. 0.333
  d. 0.294
  (e) 0.227

  $P_{pent.} = P^\circ_{pent}\,X_{pent.} = 511\,X_{pent.}$

  $P_{hex} = P^\circ_{hex}\,X_{hex.} = 150\,X_{hex} = 150(1-X_{pent.})$

  Lines intersect when $511\,X_{pent.} = 150(1-X_{pent.})$

  $X_{pent.} = \frac{150}{511+150} = 0.227$

  237.6

- HI has a normal boiling point of −35.4°C, and its ΔH_{vap} is 21.16 kJ/mol. Calculate the molar entropy of vaporization (ΔS_{vap}).

  a. 598 J/K· mol
  b. 68.6 J/K· mol
  c. 75.2 J/K· mol
  d. 0.068 J/K· mol
  (e) 89.0 J/K· mol

  $\Delta G = \Delta H - T\Delta S \equiv 0$ at equil.

  $\hookrightarrow \Delta S = \frac{\Delta H}{T} = \frac{21.16\times10^3}{237.6}$

  $= 89.0$ J/mol K

- For the reaction $H_2(g) + S(s) \rightarrow H_2S(g)$

  $\Delta H^\circ = -20.2$ kJ and $\Delta S^\circ = +43.1$ J/K−1. Which of the following statements is <u>true</u>?

  a. The reaction is only spontaneous at low temperatures.
  (b.) The reaction is spontaneous at all temperatures.
  c. ΔG° becomes less favorable as temperature increases.
  d. The reaction is spontaneous only at high temperatures.
  e. The reaction is at equilibrium at 25°C under standard conditions.

  $\left.\begin{matrix}\Delta H < 0 \\ \Delta S > 0\end{matrix}\right\} \hookrightarrow$ spont. at all T!