Time : 65 minutes **Chemistry 201** **August 5, 2008**
Quiz 2

Name : KEY **Signature :** _____

Student Number : _____

Circle your **Section :** Sect.1 10:00 am
Sect. 2 11:15 am

Useful Information

Avogadro's constant, $N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$

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

Boltzmann constant, $k = 1.380 \times 10^{-23}\ \text{JK}^{-1}$

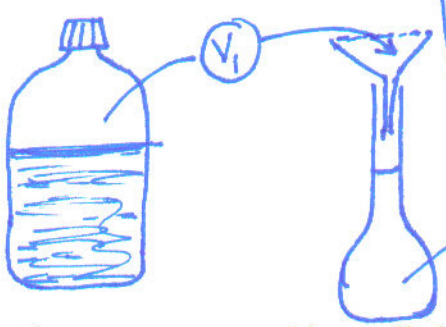
$1\ \text{atm} = 1.013 \times 10^{5}\ \text{Pa}$

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

$$M_0 = \frac{n_{H_3PO_4}}{V_2} = \frac{m_{acid}}{M_{acid} V_2} = \frac{0.85\, m_{sol}}{M_{acid} V_2} = \frac{0.85\, d_{sol} \times V_1}{M_{acid} V_2}$$

- An H_3PO_4 (Molar mass = 98.00 g/mol) stock solution bottle is labeled 85.0 % by mass and 1.70 g/mL. What volume of this solution must be measured to prepare 500 mL of 0.525 M solution?

a. 15.44 mL
b. 17.80 mL
c. 7.57 mL
d. 53.4 mL
e. 5.93 mL



$$V_1 = \frac{M_0 M_{acid} V_2}{0.85\, d_{sol}} = \frac{0.525 \times 98.00 \times 500}{0.850 \times 1.70 \times 10^3} = 17.80\ mL$$

$V_2 = 500$ mL

- The rate of effusion of an unknown gas, measured in an effusion apparatus at 9.00 atm, is found to be 31.50 mL/min. In the same effusion apparatus and at the same temperature, the rate of effusion of O_2 gas at 5.00 atm is found to be 16.95 mL/min. What is the identity of the unknown gas?

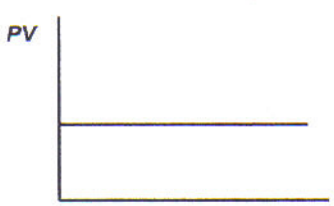
a. CO
b. CO_2
c. NO
d. NO_2
e. CH_4

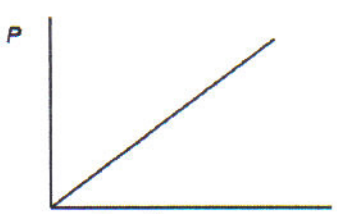
$$\frac{31.50}{16.95} = \frac{Rate_{(unk)}}{Rate_{O_2}} = \frac{P_{(unk)}}{P_{O_2}} \sqrt{\frac{M_{O_2}}{M_{(unk)}}} = \frac{9.00}{5.00} \sqrt{\frac{32.00}{M_{(unk)}}}$$

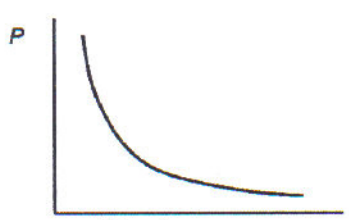
$$\Rightarrow \left(\frac{5.00 \times 31.50}{9.00 \times 16.95}\right)^2 = \frac{32.00}{M_{(unk)}} = 1.066 \rightarrow M_{(unk)} = 30.0\ g/mol$$

∴ NO is the gas

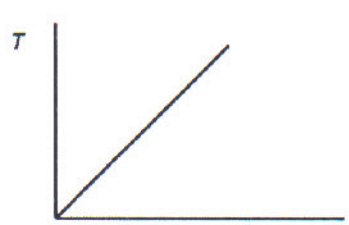
- Which of the following plots representing the gas laws is **incorrect**?

a. 

b. 

c. 

d. 

e. 

- Which of the following will have the highest total vapor pressure at 25°C?

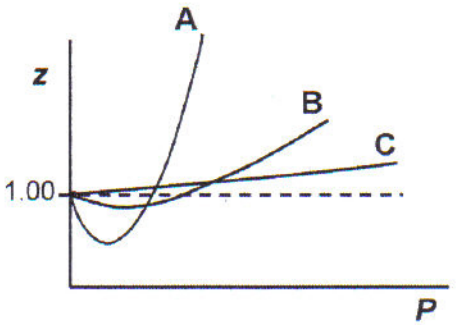
  a. pure water (vapor pressure = 23.8 torr)
  b. A solution of glucose in water with $\chi_{C_6H_{12}O_6} = 0.01$. < 23.8
  c. A solution of sodium chloride in water with $\chi_{NaCl} = 0.01$. < 23.8
  d. A solution of methanol in water with $\chi_{CH_3OH} = 0.2$ (vapor pressure of pure methanol at 25°C = 143 torr). $0.80 \times 23.8 + 0.20 \times 143 = 47.6$ Torr
  e. A solution of acetone in methanol with $\chi_{CH_3OH} = 0.64$ (vapor pressure of pure acetone at 25°C = 271 torr).

$P_{tot.} = 0.64 \times 143 + 0.36 \times 271$
$= 189$ Torr $\longrightarrow$ Highest V.P.

- Which of the following liquids, do you expect to form a solution with a *positive* deviation from Raoult's law?

  a. Acetone and water — Both polar $\longrightarrow$ (-ve)
  b. Benzene and toluene — zero
  c. Acetone and methanol — Both polar $\longrightarrow$ (-ve)
  d. Acetone and carbon tetrachloride — Polar & non-polar $\longrightarrow$ (+ve)
  e. Acetone and chloroform $\longrightarrow$ Both polar
  f. Carbon tetrachloride and carbon disulfide — Both apolar

- Which of the following statements about the Van der Waals gases (same gas at different temperatures) shown in the figures below is *correct*?



  a. Gas C has the lowest temperature. ×
  ✓ b. Gas A has the lowest temperature.
  × c. At very low *T*, only positive deviation from ideality is observed.
  × d. In gas A, the intermolecular forces are weaker than in gas B.
  ✓ e. In gas B, the departure from ideality is less pronounced than in gas A.
  No f. b) and d).
  g. b) and e)

- Which of the following statements is true about the processes of evaporation and condensation for a liquid placed in a closed container?

a. At the beginning, the rate of condensation is higher than the rate of evaporation, because there is much more liquid.
b. The rate of condensation increases as more liquid molecules enter the vapor.
c. The rate of evaporation increases as time advances. remains constant.
d. If the temperature is suddenly increased, the rate of evaporation remains constant.
e. The two rates become zero at equilibrium, and thus become equal.
f. None of the above.

- The transformation of an enzyme into a new form during a metabolitic catalysis is *exothermic* and *spontaneous*. What can be said about the structural transformation of the enzyme?

a. The new form is more ordered than the original enzyme.
b. The original enzyme could be either less ordered or more ordered than the new form.
c. The original enzyme is more ordered than the new form.
d. If the new form is less ordered than the original enzyme, then the reaction will be spontaneous at all temperatures.
e. b) and d).

See below.

- A solution is made by mixing 25.0 g of acetone (CH_3COCH_3, Vapor pressure = 271 torr) and 35.0 g of methanol (CH_3OH, Vapor pressure = 143 torr). Calculate the mole fraction of methanol in the first collection of distillate.

0.431 mol

1.09 mol

$\begin{cases} \chi_{meth.} = 0.717 \\ \chi_{ace.} = 0.283 \end{cases}$

a. 0.430
b. 0.717
c. 0.570
d. 0.283
e. 0.361

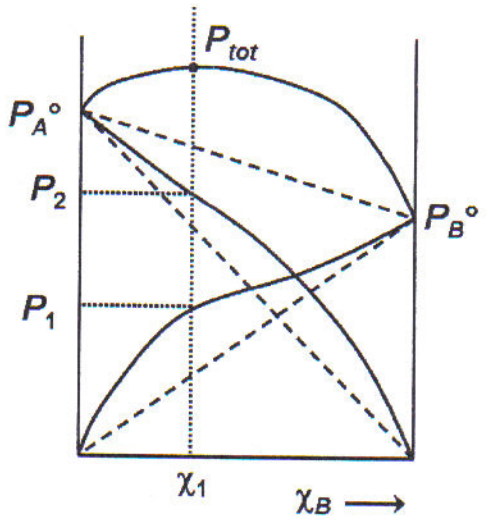
$P_{tot} = 0.717 \times 143 + 0.283 \times 271$
$= 179$ torr

hence $y_{meth.} = \dfrac{P_{meth}}{P_{total}} = \dfrac{0.717 \times 143}{179} = 0.570$

* If spontaneous at specific T, then correct answers are (b) and (d).

* If spontaneous at all T, then correct answers are (c) and (d)

- Consider the following vapor pressure-composition diagram for a binary solution of two liquids *A* and *B*.



Which of the following statements is true?

× a. *A* and *B* form an ideal solution. No! +ve deviation
× b. $\Delta H_{soln} < 0$ No. $\Delta H > 0$
× c. $P_A = P_A^\circ \chi_A$ and $P_B = P_B^\circ \chi_B$ No. Not ideal → does not obey Raoult's law
✓ d. At mole fraction χ_1, the vapor pressure of the solution is $P_{tot} = P_1 + P_2$.
× e. The vapor pressure of the solution at a given mole fraction is lower than that of an ideal solution of *A* and *B* of the same mole fraction. No! higher

- When will a chemical reaction be non-spontaneous at any temperature?

a. When $\Delta H^\circ_{rxn} > 0$ and $\Delta S^\circ_{rxn} < 0$
b. When $\Delta H^\circ_{rxn} > 0$ and $\Delta S^\circ_{rxn} > 0$
c. When $\Delta H^\circ_{rxn} < 0$ and $\Delta S^\circ_{rxn} > 0$
d. When $\Delta H^\circ_{rxn} < 0$ and $\Delta S^\circ_{rxn} < 0$
e. None of the above

- Calculate the molarity of a 0.375 *m* solution (M = 58.08 g/mol; d = 0.788 g/cm^3) in ethanol (M = 46.07 g/mol; d = 0.789 g/cm^3).

a. 0.290 M
b. 0.449 M
c. 0.375 M
d. 0.746 M
e. 0.772 M

Take $m_{eth.} = 1.000\ kg = 1000\ g$.

$n_{ace.} = 0.375\ mol \Rightarrow m_{ace.} = 58.08 \times 0.375 = 21.8\ g$

$m_{total} = 1000 + 21.8 = 1021.8\ g$

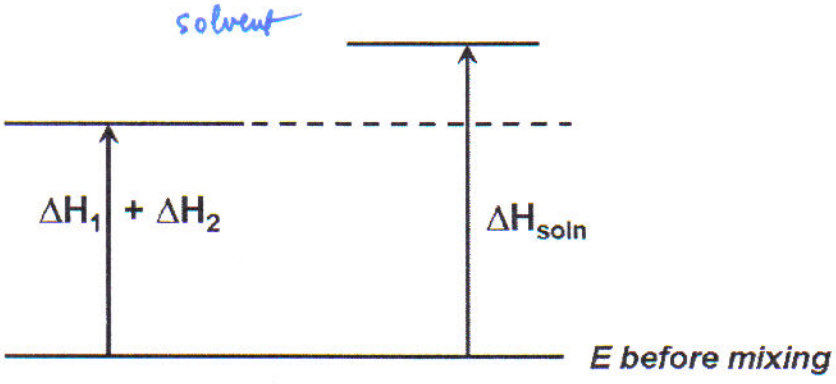
$V_{eth.} = \frac{m_{eth.}}{d_{eth.}} = \frac{1000}{0.789} = 1,267\ mL$

$V_{ace.} = \frac{21.8}{0.788} = 27.7\ mL$

$V_{tot.} = 1,267 + 27.7 = 1,295\ mL = 1.295\ L$

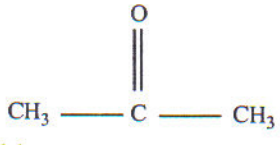
$M_0 = \frac{n_{ace}}{V_{tot}} = \frac{0.375}{1.295} = 0.290\ M$

- What can be said about the dissolution process represented by the following energy diagram? Given: the ~~solute~~ solvent is polar.



a. The mixing process between the solute and the solvent is energetically favored.
b. The dissolution process is exothermic.
c. It takes more energy to mix the solute and the solvent than to expand them both.
d. $\Delta H_3 > 0$
e. The solute is most likely to be polar. No because mixing with the solvent is not favored.

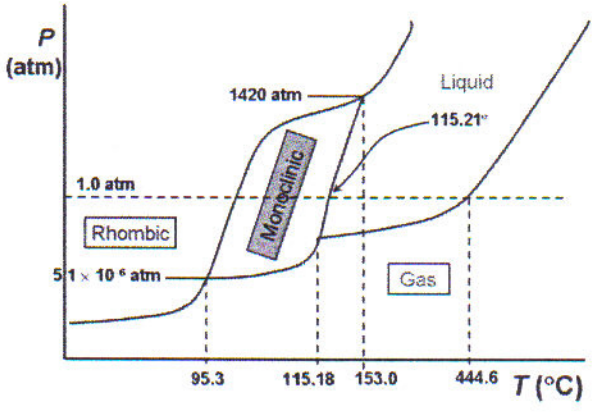
- Which of the following would have a high solubility in carbon tetrachloride (CCl_4)?

a. CO_2
b. NH_4NO_3
c. Acetone 
d. Acetic acid
e. $CH_3CH_2CH_2CH_2CH_3$
f. a) and e)
g. c) and e)

- Which of the following statements is correct?

a. Osmotic pressure is equivalent to the pressure we need to apply to stop the flow of solvent into the solution through the semi-permeable membrane.
b. Cells bathed in a hypertonic solution experience crenation and thus swell.
c. Cells bathed in a hypotonic solution experience hemolysis and thus shrink.
d. Osmosis takes place spontaneously from the solution compartment into the pure solvent through a semi-permeable membrane.
e. Osmometry is the mere performance of osmotic pressure measurements.

- Consider the following is the phase diagram of sulfur, which has two crystalline solid forms (rhombic and monoclinic).



Which of the following statements is **false**?

✓ a. Sulfur has three triple points.
✓ b. The normal boiling point of sulfur is 444.6°C.
✓ c. At 100°C and 1.00 atm, the stable phase is solid monoclinic.
✓ d. Sulfur can sublime at a pressure of 1.00×10^{-5} atm.
e. When the pressure on a sample of sulfur at 100°C is increased from 1.00×10^{-8} atm to 1500 atm, sulfur changes from gas to liquid to solid monoclinic.

No: gas to monoclinic to rhombic!

- Which of the following statements/expressions about the kinetic molecular theory (KMT) of ideal gases, or non-perfect gases is false?

✓ a. $pV = \frac{1}{3} n M \overline{u^2}$, where n = number of moles; M = molar mass. $\frac{1}{3} n M \overline{u^2} = \frac{1}{3} \frac{N}{N_A} M \overline{u^2}$ (M = mass of one molecule)

X b. For effusion in the same apparatus: $\frac{Rate\ gas\ 2}{Rate\ gas\ 1} = \frac{P_1}{P_2}\sqrt{\frac{M_2}{M_1}}$

✓ c. A simplified Van der Waals equation considering the molecular volume factor alone and ignoring the intermolecular attractive forces would be: $P(V - nb) = nRT$.

✓ d. The rate of diffusion is influenced by the intermolecular collisions.

✓ e. The mean free path decreases with increasing gas pressure; and a longer mean free path (λ) yields a higher rate of diffusion.

$n = 2.89\ mol$

- How much energy (heat) is required to convert 52.0 g of ice at -10.0°C to steam at 100°C? Given:

specific heat of ice:	2.09 J/g •°C	ΔH_{fus} = 6.02 kJ/mol
specific heat of water:	4.18 J/g •°C	ΔH_{vap} = 40.7 kJ/mol
specific heat of steam:	1.84 J/g •°C	

a. 2,570 kJ
b. 1,086 kJ
c. 40.2 kJ
(d.) 157.8 kJ
e. 22,957 kJ

$\Delta H_{tot.} = 52.0 \times 2.09 \times (10) + 2.89 \times 6.02 \times 10^3 + 52.0 \times 4.18 \times (100) + 2.89 \times 40.7 \times 10^3$ + ... No further heating!

$= 157.8 \times 10^3\ J = \boxed{157.8\ kJ}$

- A person accidentally swallows a drop of liquid oxygen (0.050 mL), which has a density of 1.149 g/mL. What volume of gas will be produced in the person's stomach at body temperature (37°C) and a pressure of 1.00 atm?

a. 4.47 L
b. 3.14 L
(c.) 45.7 mL
d. 91.3 L
e. 57.0 mL

$m_{O_2} = d_{liq} \times V_{liq} = 1.149 \times 0.050 = 0.0575\ g$

$n_{O_2} = \frac{0.0575}{32.00} = 1.80 \times 10^{-3}\ mol$

$V_{gas} = \frac{n_{O_2} RT}{P} = \frac{1.80 \times 10^{-3} \times 0.08206 \times (37+273)}{1.00} = 0.0457\ L = 45.7\ mL$

- 20.0 g of an unknown compound are dissolved in 800 g of benzene. The freezing point of the solution was measured to be 4.580°C. The freezing point of pure benzene is 5.444°C and the freezing point depression constant of benzene is 5.12°C/*m*. What is the molar mass of the unknown compound?

a. 123 g/mol
b. 68.1 g/mol
(c.) 148 g/mol
d. 54.0 g/mol
e. 27.9 g/mol

$\Delta T_f = |5.444 - 4.580| = 0.864$

$\Delta T_f = K_f\, m_0 \Rightarrow m_0 = \frac{0.864}{5.12} = 0.169\ m$

$m_0 = \frac{n_{(unk)}}{m_{benzene}} \Rightarrow n_{unk.} = m_0 \times m_{benzene}$

$= 0.169 \times 0.800\ (kg)$

$= 0.135\ mol$

$M_{(unk)} = \frac{m_{(unk)}}{n_{(unk)}} = \frac{20.0}{0.135} = \boxed{148\ g/mol}$