THE OPEN UNIVERSITY OF SRI LANKA

B. Sc. Degree Programme — Level 4
Assignment III (Test) — 2013/2014
CMU 2220/CME4220 — Concepts in Chemistry

1 hour

16th August 2014 (Saturday) 2.30 p.m. — 3.30 p.m.

- Answer all 25 questions (25 x 4 = 100 marks)
- Choose the most correct answer to each of the questions and mark this answer with an "X" on the answer script in the appropriate box.
- Use a **PEN** (not a PENCIL) in answering.
- Any answer with more than **one** "X" marked will be considered as an *incorrect* answer.
- Marks will be deducted for incorrect answers (0.6 per wrong answer).
- The use of a non-programmable electronic calculator is permitted.
- Mobile phones are **not** allowed.

- Please write your mailing address on the back of the MCQ answer sheet.

Gas constant (R)	=	$8.314\ JK^{-1}mol^{-1}$
Avogadro constant (N_A)	=	$6.023\times10^{23}\ mol^{-1}$
Faraday constant (F)	=	$96{,}500\ Cmol^{-1}$
Planck constant (h)	=	$6.63\times10^{-34}\ Js$
Velocity of light (c)	=	$3.0\times10^{8}\ ms^{-1}$
Protonic charge (e)	=	$1.602\times10^{-19}\ C$
Standard atmospheric pressure	=	$10^{5}\ Pa\left(Nm^{-2}\right)$
$Log_e(X)$	=	$2.303\ Log_{10}(X)$

1. Consider the following system in equilibrium.

   $NH_4Cl(solid) \rightleftharpoons NH_3(gas) + HCl(gas)$

   According to the phase rule, the number of independent components and the number of phases, respectively, are

   (a) 2 and 1 (b) 1 and 2 (c) 3 and 2
   (d) 2 and 3 (e) 2 and 2

2. Molality is defined as the number of moles of solute per kilogram of solvent. If an aqueous solution of a compound A is prepared by dissolving 36.0 g of A (relative molar mass = 40) in 90 g of water, the molality of A is (in moles per kilogram)

   (a) 0.1 (b) 81.0×10^{-3} (c) 10.0
   (d) 1.0 (e) 8.1×10^{-2}

3. A solution is made by mixing Y g of acetic acid and 100.0 ml of ethanol. If the mole fraction of the acid is 0.4 in this solution, then what is the value of Y? [Relative atomic mass: C=12; H = 1.0, O = 16.0. Assume that the density of ethanol $= 0.92\ g\,cm^{-3}$.]

(a) 20 (b) 40 (c) 60.0
(d) 80.0 (e) 100

4. Consider the following statements.

(i) Benzene-Toluene binary system is an example of an ideal solution.

(ii) A binary mixture that shows negative deviation from Raoults Law would show a boiling point maximum in the temperature versus composition phase diagram.

(iii) Mathematically, Raoults Law can be expressed as $P_A^0 = X_A P_A$ (where the symbols used have their usual meanings).

The correct statements out of (i), (ii) and (iii) above are
(a) Only (i) and (ii). (b) Only (i) and (iii). (c) Only (ii) and (iii).
(d) All (i), (ii) and (iii) (e) None of the statements (i), (ii) or (iii) is correct.

5. Consider the following statements with respect to a binary Azeotropic mixture.

(i) It is formed by systems that show negative deviation from Raoults Law.

(ii) Only one of the two components can be separated when subjected to fractional distillation.

(iii) None of the components can be separated when subjected to fractional distillation.

The correct statements out of (i), (ii) and (iii) above are
(a) Only (i) and (ii). (b) Only (i) and (iii). (c) Only (ii) and (iii).
(d) All (i), (ii) and (iii) (e) None of the statements (i), (ii) or (iii) is correct.

6. The following statements refer to the equation $\ln\frac{P_2}{P_1} = -\frac{\Delta H}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$ corresponding to a phase transition.

(i) It is called the Clapeyron Equation.

(ii) One of the phases should always be a gas.

(iii) Volume of gas is very much greater than that of the other (solid or liquid) phase.

The correct statements out of (i), (ii) and (iii) above are
(a) Only (i) and (ii). (b) Only (i) and (iii). (c) Only (ii) and (iii).
(d) All (i), (ii) and (iii) (e) None of the statements (i), (ii) or (iii) is correct.

7. The following statements refer to an ideal binary mixture of A and B.

   (i) The force of attraction between molecules of A is approximately equal the force of attraction between molecules of B.

   (ii) The value of total vapour pressure is independent of its composition.

   (iii) Fractional distillation can be used to separate A and B.

   The correct statements out of (i), (ii) and (iii) above are

   (a) Only (i) and (ii). (b) Only (i) and (iii). (c) Only (ii) and (iii).
   (d) All (i), (ii) and (iii) (e) None of the statements (i), (ii) or (iii) is correct.

Answers to questions (8) to (11) are based on the following information

A and B are two liquids that are miscible at all compositions and, which form an ideal solution. At 298 K, vapour pressure of pure A is 9.0×10^4 Pa . An equimolar mixture is formed by mixing 40.0 ml of A (density $=9.0\times10^2$ kg m^{-3}) with B at the above temperature. The total vapour pressure corresponding to this mixture is 1.2×10^5 Pa at 298 K. (Relative molecular masses: A= 72: B = 90)

8. The mass of B (in g) in this mixture is

   (a) 45 (b) 50 (c) 55.0
   (d) 60.0 (e) 36

9. The partial vapour pressures of A and B (in 10^4 Pa), respectively, are

   (a) 4.5 and 6.0 (b) 6.0 and 4.5 (c) 4.5 and 7.5
   (d) 7.5 and 4.5 (e) 4.5 and 7.0

10. The mole fraction of B in the vapour phase corresponding to the above mixture is, approximately,

    (a) 0.50 (b) 1.6 (c) 0.37
    (d) 0.63 (e) 0.58

11. Vapour pressure of pure B (in 10^4 Pa) at this temperature is

    (a) 9 (b) 15 (c) 12
    (d) 2.4 (e) 24

12. Which of the following consists of colligative properties?

    (a) Freezing point depression, vapour pressure depression, density.

    (b) Mass, volume, pressure.

    (c) Mass, freezing point, osmotic pressure.

    (d) Elevation of boiling point, freezing point depression, vapour pressure depression.

    (e) Temperature, pressure, volume.

13. Consider the following statements.
Dilute solutions exhibit ideal behaviour

(i) when there are intermolecular interactions.

(ii) when there are intra molecular interactions.

(iii) when there are **no** intermolecular interactions.

The correct statements out of (i), (ii) and (iii) above are

(a) Only (i). (b) Only (ii). (c) Only (iii).
(d) Only (i) and (ii). (e) Only (ii) and (iii).

14. SI units of Molality is expressed in

(a) $mol\,kg^{-1}$ (b) $mol\,dm^{-3}$ (c) $kg\,mol^{-1}$
(d) $kg\,dm^{-3}$ (e) $mol\,cm^{-3}$

15. The molar value of any extensive thermodynamic property of the i^{th} component in a closed system is referred to as a

(a) partial molar property.
(b) molar property.
(c) colligative property.
(d) intensive property.
(e) path property.

16. Partial molar volume of A in a binary ideal solution containing components A and B is represented by

(a) $\bar{V}_A = \left(\frac{\partial V}{\partial n_A}\right)_{T,P,n_B}$ (b) $\bar{V}_A = \left(\frac{\partial n_A}{\partial V}\right)_{T,P,n_B}$ (c) $V_A = \left(\frac{\partial V}{\partial n_A}\right)_{T,P,n_B}$

(d) $V_A = \left(\frac{\partial n_A}{\partial V}\right)_{T,P,n_B}$ (e) $V_A = \left(\frac{\partial \bar{V}}{\partial n_A}\right)_{T,P,n_B}$

17. For a binary mixture containing two components A and B, the Gibbs Duhem equation can be expressed as,

(a) $X_A\,d\bar{J}_A - X_B\,d\bar{J}_B = 1$ (b) $X_A\,d\bar{J}_A + X_B\,d\bar{J}_B = 1$ (c) $X_A\,d\bar{J}_A - X_B\,d\bar{J}_B = 0$

(d) $X_A\,d\bar{J}_A + X_B\,d\bar{J}_B = 0$ (e) $X_A\,d\bar{J}_B + X_B\,d\bar{J}_A = 1$

18. The pressure coefficient of chemical potential at constant temperature in a closed system is equal to

(a) Partial molar volume.
(b) Partial molar enthalpy.
(c) Partial molar entropy.
(d) Partial molar Gibbs free energy.
(e) None of the above answers.

19. One mole of an ideal gas expands slowly, isothermally at temperature T, until the volume is doubled. The change of entropy ΔS, of this gas for this process is,

(a) $\ln(2)/2$ (b) $2R$ (c) Zero

(d) $R\ln(2)$ (e) $RT\ln(2)$

20. The partial molar volumes of water and methanol are $17.8\ cm^3\ mol^{-1}$ and $38.4\ cm^3\ mol^{-1}$ respectively, at $25°C$ for a dilute mixture of methanol and water. Calculate the total volume when $15\ cm^3$ of methanol is added to $250\ cm^3$ of water at this temperature. The density of methanol is $0.791\ g\ cm^{-3}$.

(a) $265\ cm^3$ (b) $269\ cm^3$ (c) $261\ cm^3$

(d) $235\ cm^3$ (e) $254\ cm^3$

21. Calculate the change in the molar entropy of a perfect gas when it is compressed isothermally from a pressure of 1 atm to 10 atm,.

(a) $83.1\ J\ K^{-1}\ mol^{-1}$ (b) $-0.1914\ atm\ K^{-1}\ mol^{-1}$ (c) $7.6\ atm\ K^{-1}\ mol^{-1}$

(d) $0.1914\ atm\ K^{-1}\ mol^{-1}$ (e) $1.914\ atm\ K^{-1}\ mol^{-1}$

22. A particular reaction at 300K is found to be non-spontaneous when $\Delta H > 0$ and $\Delta S < 0$. Consider the following statements .
The reaction proceeds spontaneously if the,

(i) temperature is increased.

(ii) temperature is decreased.

(iii) temperature is constant.

The correct statements out of (i), (ii) and (iii) above are

(a) Only (i). (b) Only (ii). (c) Only (iii).

(d) Only (i) and (ii) (e) All (i), (ii) and (iii).

23. What is the change in entropy that occurs when 10 mol of a diatomic gas (assumed to behave ideally) are heated from $27°C$ to $2727°C$ in a bomb calorimeter?

(a) $35 \times 2.303R$ (b) $3.5 \times 2.303R$ (c) $25R$

(d) $15 \times 2.303R$ (e) $25 \times 2.303R$

Please see the next page

24. What is the system that the equation $\Delta S = nC_P \ln\left(\frac{T_2}{T_1}\right) + nR \ln\left(\frac{P_1}{P_2}\right)$ is applicable for a change of state from state $A(P_1, T_1)$ to state $B(P_2, T_2)$?

(a) An ideal gas at constant temperature only.

(b) An ideal gas at constant pressure only.

(c) Ideal gas under all conditions.

(d) Any homogeneous system at constant volume.

(e) Any homogeneous system under all conditions.

25. For a spontaneous process in a system which one of the following expressions will **NOT** apply?

(i) $dG_{P,T} < 0$ (ii) $dA_{P,T} < 0$ (iii) $dS_{sys} > dq_{rev}/T$

(a) Only (i). (b) Only (ii). (c) Only (iii).
(d) Only (ii) and (iii) (e) Only (i) and (iii).