THE OPEN UNIVERSITY OF SRI LANKA

B. Sc. Degree Programme — Level 4

Assignment II (Test) — 2014/2015

CMU 2220/CME4220 — Concepts in Chemistry

1 hour

7^{th} March 2015 (Saturday) 1.00 p.m. — 2.00 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)	=	$96,500\ C\,mol^{-1}$
Planck constant (h)	=	$6.63\times10^{-34}\ J\,s$
Velocity of light (c)	=	$3.0\times10^{8}\ m\,s^{-1}$
Protonic charge (e)	=	$1.602\times10^{-19}\ C$
Standard atmospheric pressure	=	$10^5\ Pa\left(N\,m^{-2}\right)$
$Log_e(X)$	=	$2.303\ Log_{10}(X)$

1. What is the total charge on 1.2 mole of CO_3^{2-}?

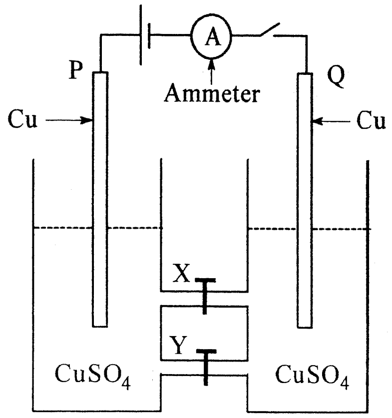
   (a) 231600 C (b) −231600 C (c) 115800 C
   (d) −115800 C (e) −347400 C

2. A strong electrolyte, AB, dissociates in aqueous medium as $AB(s) \rightarrow A^{3+}(aq) + B^{3-}(aq)$. The ionic mobilities $\left(\text{in units of } m^2\ V^{-1}s^{-1}\right)$ of $A^{3+}(aq)$ and $B^{3-}(aq)$ in a $0.2\ mol\ dm^{-3}$ solution of AB at $25^{o}C$ are 55.0×10^{-9} and 79.1×10^{-9}, respectively. What is the molar conductivity, in units $S\ m^2\ mol^{-1}$, of AB in this solution?

   (a) 0.0388 (b) 0.0194 (c) 0.388 (d) 0.0106 (e) 0.0153

Use the following data in answering questions 3, 4, 5 and 6.

A student electrolysed an aqueous solution of copper sulphate using two copper electrodes using the apparatus shown in the figure. The left and right hand chambers are connected with glass tubes X and Y, fitted with taps so that the electric current through each of the tubes can be stopped by closing each of them. During the electrolysis experiment, he maintained a constant ammeter reading of 2.1 A for 20 s.



During the above mentioned experiment, the student found that the electric current through tube X remained constant at 1.3 A. Also the transport number of copper ions in tube Y was found to be 0.6.

[Relative atomic mass of copper is 63.5]

3. Consider the following statements about the above mentioned experiment.
   (i) The copper ions in tube X moved toward the chamber with the electrode Q (i.e. the chamber on the right hand side of the figure).
   (ii) Mass of electrode P increased.
   (iii) The electric current in tube Y was equal to 0.8 A.

   The correct statement/s 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) Only (i)

4. What would have happened to the ammeter reading if the student closed tap X, (without doing any other changes) during the above mentioned experiment?
   (a) Remained to be same as 2.1 A.
   (b) Would have increased to a value greater than 2.1 A.
   (c) Would have decreased to a value smaller than 2.1 A.
   (d) Would have Increased and decreased around 2.1 A.
   (e) First increase above 2.1 A and then decrease up to a value greater than 2.1 A.

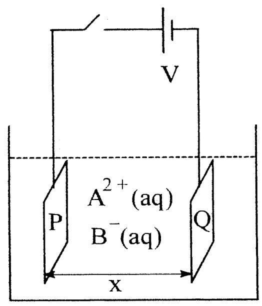
5. What was the mass of copper deposited (on P or Q) during the experiment?
   (a) 0.0171g (b) 0.0083 g (c) 0.0166 g (d) 0.0276 g (e) 0.0138 g

6. What was the rate of flow of copper ions, in units of mol s^{-1}, in tube Y during the experiment?
   (a) 4.97×10^{-6} (b) 8.29×10^{-6} (c) 4.14×10^{-6}
   (d) 2.49×10^{-6} (e) 6.22×10^{-6}

7. A silver nitrate solution was electrolysed using two silver plates. The current density (which was uniform in the solution) was determined to be $2.5\ \text{A m}^{-2}$. What is the electric field strength in the solution if the conductivity of it is $0.05\ \text{S m}^{-1}$?

(a) $5.0\ \text{V m}^{-1}$ (b) $0.5\ \text{V m}^{-1}$ (c) $50.0\ \text{V cm}^{-1}$
(d) $0.125\ \text{V m}^{-1}$ (e) $0.5\ \text{V cm}^{-1}$

8. Using the setup shown in the figure, a student electrolysed a dilute aqueous solution of a strong electrolyte AB_2 which dissociates as $AB_2(s) \rightarrow A^{2+}(aq) + 2B^{-}(aq)$. P and Q are two platinum electrodes. The distance and the potential difference between P and Q were x and V, respectively. Consider the following statements.



(i) The drift speed of $A^{2+}(aq)$ increases when V is increased keeping x constant.
(ii) The drift speed of $B^{-}(aq)$ decreases when x is increased keeping V constant.
(iii) Ionic mobility of $A^{2+}(aq)$ remains the same when V is increased keeping x constant.

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) Only (i)

9. A student prepared a solution, Z, of a *weak electrolyte* X_2Y by dissolving 1 mole of pure X_2Y in one litre of solution using distilled water. X_2Y dissociates as $X_2Y(aq) \rightleftharpoons 2X^{+}(aq) + Y^{2-}(aq)$. Consider the following statements.

(i) The *molar conductivity* of X_2Y in the solution increases when more and more distilled water is added to Z.
(ii) The *conductivity* due to X_2Y in the solution increases when more and more distilled water is added to Z.
(iii) The molar conductivity of X_2Y, Λ_{X_2Y}, in solution Z is given by $\Lambda_{X_2Y} = 2\lambda_{X^+} + \lambda_{Y^{2-}}$ where λ_{X^+} and $\lambda_{Y^{2-}}$ are the molar conductivities of $X^{+}(aq)$ and $Y^{2-}(aq)$ ions in Z, respectively.

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) Only (i)

10. Ionic mobility of an ionic species in a solution at a particular temperature
(i) depends on the solvent.
(ii) is defined as the drift speed per unit electric field strength.
(iii) has the unit $m^2\ V^{-1}\ s^{-1}$.

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) only (i).

11. What is the most probable relationship if the limiting ionic mobility of an ionic species B in aqueous medium at $25^{\circ}C$ is denoted by u_B^0?

(a) $u^0_{H^+} > u^0_{OH^-} > u^0_{CH_3COO^-}$

(b) $u^0_{CH_3COO^-} > u^0_{H^+} > u^0_{OH^-}$

(c) $u^0_{OH^-} > u^0_{CH_3COO^-} > u^0_{H^+}$

(d) $u^0_{OH^-} > u^0_{H^+} > u^0_{CH_3COO^-}$

(e) $u^0_{H^+} > u^0_{CH_3COO^-} > u^0_{OH^-}$

12. Consider the following statements about the moving boundary method for the determination of ionic mobility of an ionic species in a solution A.

(i) One may use a colourless following solution in the case where A is also colourless.
(ii) The density of the following solution must always be greater than that of solution A.
(iii) Always solution A must be kept in the compartment above the compartment having the following solution.

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) Only (i).

13. Consider a dilute aqueous solution of $Mg(NO_3)_2$ and $AlCl_3$. If a constant current of I is passed through the solution for a short period of time δt, then the transport number of Al^{3+}, $t_{Al^{3+}}$, in this solution may be written as

(i) $t_{Al^{3+}} = Q_{Al^{3+}} / (I\ \delta t)$ where $Q_{Al^{3+}}$ is the total charge carried by Al^{3+} ions (through a cross section of the solution) during the time interval δt.

(ii) $t_{Al^{3+}} = \kappa_{Al^{3+}} / \left(\kappa_{AlCl_3} + \kappa_{Mg(NO_3)_2}\right)$ where κ_α is the conductivity of chemical species α in the solution.

(iii) $t_{Al^{3+}} = I_{Al^{3+}} / I$ where $I_{Al^{3+}}$ is the current carried by Al^{3+} ions during the passage of the current I.

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) Only (i).

14. The molar conductivities (in units of $S\,m^2\,mol^{-1}$) of calcium and thiocyanate ions, in a solution of $Ca(CNS)_2$ at 25^0C and at 1 atm, are 1.2×10^{-2} and 6.2×10^{-3} respectively. What is the molar conductivity (in units of $S\,m^2\,mol^{-1}$) of calcium thiocyanate in this solution if it behaves as a strong electrolyte?

(a) 0.0182
(b) 0.0170
(c) 0.182
(d) 0.0034
(e) 0.0244

15. Consider the following mathematical relationships made on a dilute aqueous solution of $Cu(NO_3)_2$, with all the symbols having their usual meanings.

(i) $\kappa_{Solution} = \kappa_{Cu^{2+}} + \kappa_{NO_3^-} + \kappa_{H^+} + \kappa_{OH^-}$.

(ii) $\kappa_{Cu^{2+}} = 2u_{Cu^{2+}} c_{Cu^{2+}} F$

(iii) $\kappa_{Cu(NO_3)_2} = \kappa_{Cu^{2+}} + \kappa_{NO_3^-}$

The correct relationships 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) Only (i).

16. Which pairing of *quantity* and *its unit* is **incorrect**?

(a) Resistivity: S m

(b) Potential difference: $J C^{-1}$

(c) Drift speed (velocity): $m s^{-1}$

(d) Ionic mobility: $m^2 V^{-1} s^{-1}$

(e) Molar conductivity: $S m^2 mol^{-1}$

17. Which of the following is correct for a spontaneous process in a closed system?

(a) Entropy of the system always increases
(b) Free energy of the system always increases.
(c) Total (i.e. system + surroundings) entropy change is always negative
(d) Total (i.e. system + surroundings) entropy change is always positive
(e) No change in the entropy of the system.

18. For a closed system at constant temperature and pressure the Gibbs free energy change ΔG_{sys} is

(i) negative when a process is <u>not</u> spontaneous.
(ii) positive when a process is spontaneous
(iii) zero when a system is at equilibrium

The correct statement/s out of (i), (ii) and (iii) above is/are
(a) Only (i). (b) Only (ii). (c) Only (iii).
(d) Only (i) and (iii) (e) Only (ii) and (iii).

19. In a closed system at constant pressure a reaction occurs spontaneously if,

(a) $T\Delta S < \Delta H$ and ΔH is positive and ΔS is positive.

(b) $T\Delta S > \Delta H$ and ΔH is positive and ΔS is negative.

(c) $T\Delta S > \Delta H$ and ΔH is positive and ΔS is positive.

(d) $T\Delta S = \Delta H$ and ΔH is positive and ΔS is positive.

(e) $T\Delta S = \Delta H$ and ΔH is positive and ΔS is negative.

20. What is the entropy change for the fusion of 1 mol of a solid melting at $27^{o}C$ if the latent heat of fusion of the solid is $2930\ J\ mol^{-1}$?

(a) $9.77\ J\ K^{-1}$ (b) $10.73\ J\ K^{-1}$ (c) $2930\ J\ K^{-1}$
(d) $108.5\ J\ K^{-1}$ (e) $29.30\ J\ K^{-1}$

21. What is the entropy change when 0.5 mol of an ideal gas expands at constant temperature from an initial volume of $10\ dm^3$ to a final volume of $75\ dm^3$?

(a) 7.367 J / K (b) 8.376 J / K (c) 4.188 J / K
(d) 16.75 J / K (e) 0 J / K

22. Which of the process/s given below follow/s the equation $\Delta S = q_{rev} / T$?

(i) Reversible. (ii) Isothermal (iii) Isobaric

The correct process/s out of (i), (ii) and (iii) above is/are

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

23. The Kirchoff's equation is given as,

(a) $\Delta H_{T_2} = \Delta H_{T_1} + \Delta C_P (T_2 - T_1)$

(b) $\Delta H_{T_1} = \Delta H_{T_2} + \Delta C_P (T_2 - T_1)$

(c) $\Delta H_{T_2} = \Delta H_{T_1} + \Delta C_P (T_1 - T_2)$

(d) $\Delta H_{T_1} = \Delta H_{T_2} + \Delta C_P (T_2 + T_1)$

(e) $\Delta H = R \Delta C_P (T_2 - T_1)$

24. The Maxwell relationship that can be derived from the equation, $dG = V\,dP - S\,dT$ is,

(a) $\left(\frac{\partial P}{\partial T}\right)_V = \left(\frac{\partial S}{\partial V}\right)_T$ (b) $\left(\frac{\partial T}{\partial S}\right)_V = \left(\frac{\partial V}{\partial P}\right)_T$

(c) $\left(\frac{\partial V}{\partial T}\right)_T = -\left(\frac{\partial S}{\partial P}\right)_P$ (d) $\left(\frac{\partial V}{\partial T}\right)_P = -\left(\frac{\partial S}{\partial P}\right)_T$

(e) $\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V$

25. The Clapeyron equation gives the variation of

(a) vapour pressure of a reversible phase transition of a univariant system.
(b) vapour pressure of an isothermal system.
(c) temperature of an isobaric system.
(d) enthalpy change of a reversible phase transition.
(e) entropy change of a reversible phase transition.