

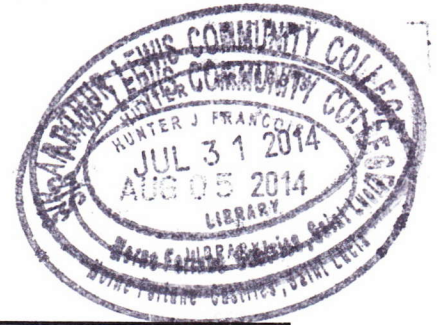
SIR ARTHUR LEWIS COMMUNITY COLLEGE

DIVISION OF TECHNICAL EDUCATION & MANAGEMENT STUDIES

EXAMINATION SESSION : May 2014 Final Examination
LECTURER(S) : M. Charles, A. W-Henry
PROGRAMME TITLES : Construction Engineering,
 Architectural Technology,
 Quantity Surveying & Agriculture
COURSE TITLE : CHEMISTRY
COURSE CODE : CHM102
LEVEL : ONE
DATE : Thursday 15th May 2014
TIME : 9:00 am
DURATION : 3 hours
ROOM(S) : TRB-Lab
INVIGILATORS : K. Numa, S. Herelle

RESERVE

05 MAY

C43**INSTRUCTIONS**

1. This is a THREE hour examination consisting of **twelve (12) pages** and a Periodic Table.
2. This paper has three Sections: Section A, B and C
 - a. Section A (Multiple Choice) and Section B are compulsory sections
 - b. Section C: You must choose ANY TWO questions to answer
3. Answer all questions in the answer booklet provided.
4. For numerical problems, ALL working must be shown for full marks.
5. Use of pocket electronic calculators is permitted.
6. MEMORY CONTAINING PROGRAMABLE CALCULATORS ARE NOT PERMITTED UNLESS THE MEMORY IS DUMPED OF CHEMISTRY RELATED EQUATIONS.
7. All cell phones must be turned off. Place cell phone on front desk if leaving the room during the examination period to go to the washroom.

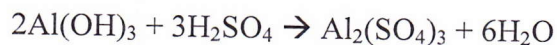
DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO

SECTION A

MULTIPLE CHOICE QUESTIONS

Shade the letter that corresponds to the correct answer for each question.

1. Aluminum sulphate can be manufactured in a chemical process as shown in the following equation:



How many moles of sulphuric acid are needed to produce 0.40 mol of aluminium sulphate?

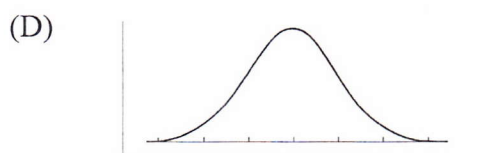
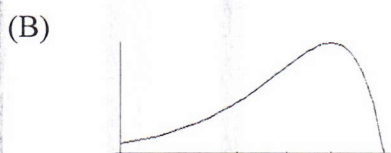
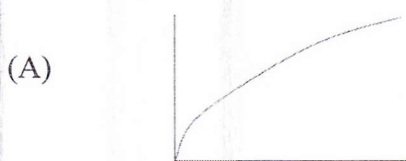
- (A) 0.6 (B) 2.0 (C) 1.6 (D) 3.0
2. Which of the following BEST describes a limiting reagent?
- (A) The reactant that is not completely used up in a chemical reaction.
(B) The product that is not completely used up in a chemical reaction.
(C) The reactant that is completely used up in a chemical reaction.
(D) The product that is completely used up in a chemical reaction.
3. What is the name of the salt that is formed from the reaction between hydrochloric acid and sodium hydroxide?
- (A) Hydrogen hydroxide
(B) sodium hydrochloride
(C) sodium Hydride
(D) sodium chloride
4. In the following reaction: $2\text{C}_2\text{H}_6 + 7\text{O}_2 \rightarrow 4\text{CO}_2 + 6\text{H}_2\text{O}$, what is the ratio of carbon dioxide to carbon ethane?
- (A) 2:1 (B) 4:7 (C) 7:4 (D) 7:6
5. John weighed a 20.0 g sample of sodium carbonate (Na_2CO_3) to be used in the laboratory to perform an experiment. How many moles of sodium carbonate is contained in this sample?
- (A) 1.89 mol
(B) 212 mol
(C) 2.12×10^3 mol
(D) 0.189 mol

GO ON TO THE NEXT PAGE

6. Which of the following statements is TRUE about ideal gases?
- (A) Gas particles are very attracted to one another
 (B) Gas particles are very large and occupy a large portion of the container it is placed in.
 (C) Energy is lost by collisions of gas particles with the walls of the container or with each other
 (D) Gas particles move in straight lines in all directions colliding frequently with one another and the sides of the container
7. What is the oxidation state of Mn in KMnO_4 ?
- (A) +3 (B) +7 (C) -7 (D) 0
8. Which of the following half reactions does not represent the oxidation half of a redox reaction?
- (A) $\text{Mg (s)} \rightarrow \text{Mg}^{2+} \text{(aq)}$
 (B) $2\text{Cl}^- \text{(aq)} \rightarrow \text{Cl}_2 \text{(g)}$
 (C) $\text{Sn}^{2+} \text{(aq)} \rightarrow \text{Sn}^{4+} \text{(aq)}$
 (D) $\text{Cu}^{2+} \text{(aq)} \rightarrow \text{Cu}^+ \text{(aq)}$
9. In the reaction, $\text{Cu}^{2+} + \text{Zn} \rightarrow \text{Cu} + \text{Zn}^{2+}$, the reducing agent is:
- (A) Zn (B) Zn^{2+} (C) Cu (D) Cu^{2+}
10. In Na_2SO_4 , the oxidation number of sulphur is:
- (A) +2 (B) +6 (C) +4 (D) -2
11. Pick out the statement that correctly defines an oxidizing agent in a redox reaction.
- (A) The oxidizing agent causes another substance to be oxidized and gains electrons
 (B) The oxidizing agent causes another substance to be reduced and gains electrons
 (C) The oxidizing agent is the substance that is oxidized in the redox reaction
 (D) The oxidizing agent loses electrons in a redox reaction and is reduced.
12. In the electrolysis of molten copper (II) sulphate using copper electrodes, the substance formed at the anode is
- (A) oxygen (B) copper (C) chlorine (D) hydrogen
13. Which two of the following equations represent the reaction taking place at the electrodes when copper sulphate solution is electrolyzed using copper electrodes?
- I $\text{Cu (s)} \rightarrow \text{Cu}^{2+} + 2\text{e}^-$
 II $\text{SO}_4^{2-} \text{(aq)} \rightarrow \text{SO}_4 \text{(aq)} + 2\text{e}^-$
 III $4\text{OH}^- \text{(aq)} \rightarrow 2\text{H}_2\text{O (l)} + \text{O}_2 \text{(g)} + 4\text{e}^-$
 IV $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu (s)}$
- (A) I and III
 (B) I and IV
 (C) II and III
 (D) II and IV

GO ON TO THE NEXT PAGE

14. Which of the following will NOT conduct electricity?
- (A) Solid sodium
 (B) Solid sodium chloride
 (C) A solution of sodium chloride in water
 (D) Molten sodium chloride
15. What is the term for the electrode where oxidation occurs?
- (A) anode (B) cathode (C) oxidizing agent (D) reducing agent
16. What are the oxidation states of vanadium in the ions VO^{2+} and VO_4^{3-} respectively?
- (A) +4 and +5 (B) +4 and +8 (C) +6 and +5 (D) +6 and +8
17. Identify the substance below that would be an active electrode in electrolysis.
- (A) Carbon (B) Copper (C) Titanium (D) Graphite
18. Aluminum is in group III of the periodic table. How many moles of product would be formed by the passage of 193000 C of electricity? $1 \text{ mol} = 96500 \text{ C/mol}$
- (A) 0.002 (B) 0.02 (C) 0.2 (D) 2.0
19. Which of the following factors will increase the rate of a chemical reaction involving gases?
- (A) Decreasing the temperature
 (B) Adding less reactants to the mixture
 (C) Adding a catalyst
 (D) Increasing the volume of the container
20. The rate of a chemical reaction can be expressed in
- (A) grams per mole (B) energy consumed per mole
 (C) volume of gas per unit time (D) moles formed per litre of solution.
21. Which of the following graphs illustrates the Boltzmann distribution curve?



GO ON TO THE NEXT PAGE

22. Which BEST describe how a catalyst works?

- (A) Catalysts increase the rate of a chemical reaction by increasing the activation energy.
- (B) Catalysts increase the rate of a chemical reaction by increasing the concentrations of the reactants
- (C) Catalysts increase the rate of a chemical reaction by increasing the temperature of the reaction mixture.
- (D) Catalysts increase the rate of a chemical reaction by providing a different low energy mechanism for the reaction

23. The slowest step of the reaction mechanism of a chemical reaction is called _____.

- (A) Activation energy
- (B) Energy evolution step
- (C) Rate determining step
- (D) Reaction Catalyst

24. Nitrogen reacts with oxygen



At equilibrium, which statement is FALSE?

- (A) The reaction is reversible
- (B) The forward and backward reactions are taking place at the same rate
- (C) The forward reaction releases heat energy
- (D) Pressure has an effect on this system

25. The equilibrium constant for the reaction $2\text{A} + \text{B} \rightleftharpoons 3\text{C} + \text{D}$

- (A) $\frac{[\text{C}]^3[\text{D}]}{[\text{A}]^2[\text{B}]}$
- (B) $\frac{[\text{3C}][\text{D}]}{[\text{2A}]\text{B}}$
- (C) $\frac{[\text{2A}][\text{B}]}{[\text{3C}][\text{D}]}$
- (D) $\frac{[\text{A}]^2[\text{B}]}{[\text{C}]^3[\text{D}]}$

26. For which value of the equilibrium constant K_c is the reverse reaction favoured?

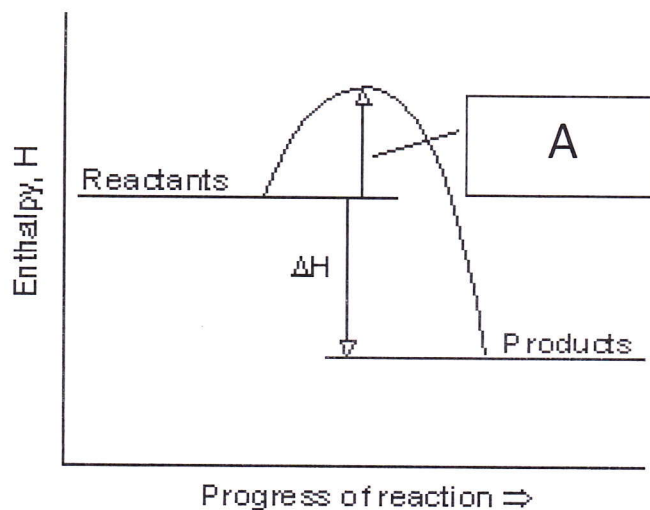
- (A) $K_c = 1$
- (B) $K_c > 1$
- (C) $K_c < 1$
- (D) $K_c = 0$

27. A chemical reaction that absorbs energy is called _____.

- (A) Endothermic reaction
- (B) Redox Reaction
- (C) Exothermic reaction
- (D) Reversible Reaction

GO ON TO THE NEXT PAGE

The diagram below represents an energy profile diagram of a chemical reaction. Refer to this diagram for questions 29 -30.



28. What measurement does A represent?
- (A) Enthalpy change
(B) Heat energy
(C) Activation energy
(D) Catalyst
29. What type of chemical reaction is BEST represented by the energy profile diagram?
- (A) Endothermic reaction
(B) Exothermic Reaction
(C) Non-spontaneous reaction
(D) Reversible reaction
30. Identify the weak acid from the list below.
- (A) HCl (B) CH_3COOH (C) HNO_3 (D) H_2SO_4

Total 30 marks

GO ON TO THE NEXT SECTION

SECTION B

This section contains three (3) compulsory questions.

Answer all questions in the booklet provided.

Show ALL working for full marks.

Question 1: STOICHIOMETRY

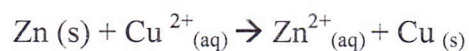
- A. 25.00 cm³ of a solution of phosphoric acid contain 4.025g H₃PO₄.
- (a) How many moles of H₃PO₄ are present in the 4.025g? (3 marks)
- (b) What is the molar concentration in mol/dm³ of this solution? (3 marks)
- B. Sulphur dioxide (SO₂) combines readily with oxygen gas (O₂) to produce sulphur trioxide (SO₃).
- $$2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{SO}_3(\text{g})$$
- 2.5g of sulphur dioxide are used in the reaction.
- (a) Determine the number of moles of sulphur dioxide present in 2.5g (3 marks)
- (b) What is the mole ratio of sulphur dioxide to sulphur trioxide? (1 mark)
- (c) How many moles of sulphur trioxide was produced? (1 marks)
- (d) Calculate the mass of sulphur trioxide produced. (2 marks)
- C. Using the ideal gas equation, $PV = nRT$
- Calculate the mass of argon inside a balloon given that the pressure inside the balloon is 0.60 atm, its volume is 2.7 L and its temperature is 25 °C.
- $$R = 0.0821 \text{ L atm K}^{-1} \text{ mol}^{-1} \quad (3 \text{ marks})$$
- D. At high temperatures, sulfur combines with iron to form the brown-black iron (II) sulfide:
- $$\text{Fe}(\text{s}) + \text{S}(\text{l}) \rightarrow \text{FeS}(\text{s})$$
- In one experiment, 7.62 g of Fe are allowed to react with 8.67 g of S.
- a. What is the limiting reagent, and what is the reactant in excess?
Show working (3 marks)
- b. Calculate the mass of FeS formed. (2 marks)
- c. Calculate the percent yield for the reaction below if 75.0 g of phosphorus reacts **with excess** chlorine gas to produce 111.0 g of phosphorus trichloride.
- $$\text{P}_4(\text{s}) + 6 \text{Cl}_2(\text{g}) \rightarrow 4 \text{PCl}_3(\text{l}) \quad (4 \text{ marks})$$

Total 25 marks

GO ON TO THE NEXT PAGE

Question 2: OXIDATION AND REDUCTION

Use the following equation to answer the questions below:



- A. Define oxidation (1 mark)
- B. Define reduction (1 mark)
- C. Which species is oxidized? (1 mark)
- D. Write the half equation for the oxidation (1 mark)
- E. Which species is reduced? (1 mark)
- F. Write the half equation for the reduction (1 mark)
- G. Which is the oxidizing agent? (1 mark)
- H. Which is the reducing agent? (1 mark)
- I. Find the oxidation state of the underlined element in the following substances:
- (a) Cr O₄²⁻
- (b) KMnO₄
- (c) K₂CrO₇
- (d) Na
- (e) Cl₂
- (5 marks)
- J. For each of the following oxidation-reduction reactions, identify which element is being oxidized and which is being reduced by writing their half equations.
- (a) Al³⁺ + Zn → Al + Zn²⁺ (4 marks)
- (b) Cl₂ + 2 Na → 2 Na⁺ + 2 Cl⁻ (4 marks)
- (c) Cl₂ + Cu → CuCl₂ (4 marks)

Total 25 marks

Question 3: ELECTROCHEMISTRY

A. Use the information below to answer the following questions:

A current of 2.68 ampere is passed for one hour through an **aqueous solution of copper sulphate using copper electrodes.**

- (a) What ions are present in the electrolyte? (1 mark)
- (b) What ions move toward the anode and the cathode respectively? (2 mark)

(c) What **3 factors** determine which ions are discharged at the electrodes? (3 marks)

(d) Which ion is discharged at the cathode? Why? (2 marks)

(e) Write the anode half equation (1 mark)

(f) Write the cathode half equation (1 mark)

(g) Calculate the quantity of electrical charge in coulombs that was passed through the compound. (2 marks)

(h) Calculate

(i) the number of moles of copper deposited on the electrode

(ii) the many grams of copper deposited

(4 marks)

B. Electrolysis was carried out continuously on a molten sample of MgCl_2 .

(a) Show a possible apparatus for this electrolysis process. (5 marks)

(b) What are the reactions at the anode and the cathode? Write the half equations to show the process taking place at each electrode (4 marks)

Total 25 marks

GO ON TO THE NEXT PAGE AND SECTION

SECTION C

This section contains THREE (3) questions.

Answer ANY TWO questions in the answer booklet provided.

Show ALL working for full marks.

QUESTION 4: REACTION KINETICS

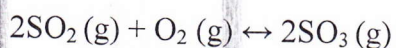
- A. Define the following terms as they relate to reaction kinetics:
- (a) Rate of reaction (1 mark)
 - (b) Catalyst (1 mark)
- B. List 2 factors which affect the rate of a chemical reaction (2 marks)
- C. The Boltzmann distribution curve below represents the effect of temperature on the rate of a chemical reaction.
- (a) Draw the Boltzmann distribution curve. Label your axes (3 marks)
 - (b) Indicate on your curve:
 - The activation energy
 - The molecules having less than the activation energy
 - The molecules having more than the activation energy (3 mark)
 - (c) Redraw your curve on a different graph. If the temperature, T_1 , was increased by $10\text{ }^\circ\text{C}$ to T_2 , draw a separate curve on this same graph to represent the effect of this increase in temperature. (2 marks)
 - (d) What effect does this increase in temperature have on the rate of the reaction? Give one explanation. (2 marks)

Total 15 marks

GO ON TO THE NEXT PAGE

QUESTION 5: EQUILIBRIUM

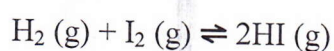
A. The reaction



reaches equilibrium in a closed system. The forward reaction is exothermic. The reaction is catalyzed by V_2O_5 .

- (a) Explain dynamic equilibrium (1 mark)
- (b) What will happen to the position of the equilibrium when:
- (i) Some SO_3 is removed from the vessel? (2 marks)
- (ii) The temperature of the vessel is increased? (2 marks)
- (iii) The pressure of the vessel is lowered? (2 marks)

B. Consider the following equilibrium reaction



At equilibrium, the concentrations of reactants and products are:

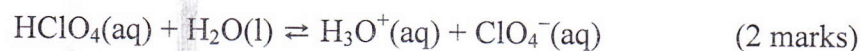
$$[\text{H}_2] = 0.20 \text{ M} \quad [\text{I}_2] = 0.50 \text{ M} \quad [\text{HI}] = 1.40 \text{ M}$$

- (a) Write the equilibrium constant expression K_c for the reaction. (2 marks)
- (b) Using this information, calculate the equilibrium constant for the reaction. (2 marks)

C. According to the Brønsted-Lowry model, define the following

- (a) A Brønsted-Lowry acid (1 mark)
- (b) A Brønsted-Lowry base (1 mark)

D. In the following chemical equation, label each compound as acid, base, conjugate acid or conjugate base.



Total 15 marks

GO ON TO THE NEXT PAGE

QUESTION 6: ENERGETICS

A. Distinguish between the following terms:

Exothermic reactions and Endothermic reactions (2 marks)

B. Draw suitable energy level diagrams to illustrate the changes taking place in the following reactions:

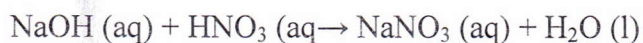
(a) 50 cm³ of sodium hydroxide (4.0M) was added to 50 cm³ of 4.0 M hydrochloric acid. When the reaction was complete, the temperature had risen by 10 °C.

(2 marks)

(b) 50.6 g of sodium nitrate were dissolved in 50 cm³ of water. The temperature fell by 16°C.

(2 marks)

C. When 25cm³ of 2.0 moldm⁻³ nitric acid were added to 25 cm³ of 2.0 moldm⁻³ sodium hydroxide in a styrofoam cup, the temperature rose from 27°C to 35°C.



(a) How many moles of sodium hydroxide are there in 25cm³ of 2.0 moldm⁻³ of solution? (2 marks)

(b) How many moles of water were produced in the above reaction? (2 marks)

(c) Calculate the heat given out in this reaction.

(Heat $\Delta H = m(\text{mass in grams}) \times c \times \Delta T$)

(1 cm³ of a dilute solution has a mass of 1 g. Take specific heat capacity of this solution to be 4200 Jg⁻¹K⁻¹).

(3 marks)

(d) What is the heat of neutralization ΔH_n° produced when 1 mol of nitric acid reacts with 1 mol of sodium hydroxide?

(2 marks)

Total 15 marks

END OF TEST

The Periodic Table of the Elements

I		II		Group										III	IV	V	VI	VII	0						
6.9 Li lithium 3	9.0 Be beryllium 4											1.0 H hydrogen 1	10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10							
23.0 Na sodium 11	24.3 Mg magnesium 12	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36								
39.1 K potassium 19	40.1 Ca calcium 20	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	- Tc technetium 43	101 Ru ruthenium 44	103 Rh rhodium 45	106 Pd palladium 46	108 Ag silver 47	112 Cd cadmium 48	115 In indium 49	119 Sn tin 50	122 Sb antimony 51	128 Te tellurium 52	127 I iodine 53	131 Xe xenon 54								
133 Cs caesium 55	137 Ba barium 56	139 La lanthanum 57	178 Hf hafnium 72	181 Ta tantalum 73	184 W tungsten 74	186 Re rhenium 75	190 Os osmium 76	192 Ir iridium 77	195 Pt platinum 78	197 Au gold 79	201 Hg mercury 80	204 Tl thallium 81	207 Pb lead 82	209 Bi bismuth 83	- Po polonium 84	- At astatine 85	- Rn radon 86								
- Fr francium 87	- Ra radium 88	- Ac actinium 89	- Rf rutherfordium 104	- Db dubnium 105	- Sg seaborgium 106	- Bh bohrium 107	- Hs hassium 108	- Mt meitnerium 109	- Unu ununium 110	- Uuu ununium 111	- Uub unubium 112	- Uuq ununquadium 114	- Uuq ununquadium 114	- Uuh ununhexium 116	- Uuo ununoctium 118	- Uuo ununoctium 118	- Uuo ununoctium 118								
		lanthanides *										140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	141 Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
		actinides *										140 Th thorium 90	141 Pa protactinium 91	144 U uranium 92	141 Np neptunium 93	150 Pu plutonium 94	152 Am americium 95	157 Cm curium 96	159 Bk berkelium 97	163 Cf californium 98	165 Es einsteinium 99	167 Fm fermium 100	169 Md mendelevium 101	173 No nobelium 102	175 Lw lawrencium 103