SIR ARTHUR LEWIS COMMUNITY COLLEGE
DIVISION OF AGRICULTURE

CHM102 – Credit Chemistry
END OF SEMESTER TWO EXAMINATION – 2018/2019

Date: 30th April, 2019

Duration: 3 hours   **Time:** 1:00 pm

Student ID Number: _____

INSTRUCTIONS

1. This is a THREE hour examination consisting of TWO Sections and a Periodic Table.

   Section A – 20 Multiple Choice Questions
   Section B – 6 Structured Questions

2. Answer ALL questions for each section in the SPACES provided.

3. For numerical problems, ALL working must be shown for full marks

4. Use of pocket electronic calculators is permitted.

IMPORTANT FIGURES FOR THE EXAM

Molar volume at r.t.p: 24.0 dm³/mol   **1F = 96500C**

Molar Volume at s.t.p: 22.4 dm³/mol   **Specific heat capacity of water= 4.18Jg⁻¹°C⁻¹**

Section	Number	Marks Earned	Maximum Marks
Section A Multiple choice	1 - 20		20 marks
Section B Structured Questions	1		20 marks
	2		20 marks
	3		20 marks
	4		15 marks
	5		15 marks
	6		15 marks
	TOTAL		125/ marks

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

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	TOTAL		120/ marks

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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:

   $$2Al(OH)_3 + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 6H_2O$$
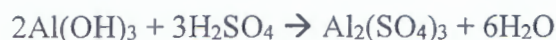
   How many moles of sulphuric acid are needed to produce 0.40 mol of aluminium sulphate?

   (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: $2 C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$, 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 half reactions does not represent the oxidation half of a redox reaction?

(A) $Mg (s) \longrightarrow Mg^{2+} (aq)$
(B) $2Cl^- (aq) \longrightarrow Cl_2 (g)$
(C) $Sn^{2+} (aq) \longrightarrow Sn^{4+} (aq)$
(D) $Cu^{2+} (aq) \longrightarrow Cu^+ (aq)$

7. In the reaction, $Cu^{2+} + Zn \rightarrow Cu + Zn^{2+}$, the reducing agent is:

(A) Zn (B) Zn^{2+} (C) Cu (D) Cu^{2+}

8. 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.

9. 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

10. Which two of the following equations represent the reaction taking place at the electrodes when copper sulphate solution is electrolyzed using copper electrodes?

I $Cu_{(S)} \rightarrow Cu^{2+} + 2e^-$
II $SO_4^{2-}{}_{(aq)} \rightarrow SO_{4\ (aq)} + 2e^-$
III $4OH^-{}_{(aq)} \rightarrow 2H_2O_{(l)} + O_{2\ (g)} + 4e^-$
IV $Cu^{2+} + 2e^- \rightarrow Cu_{(s)}$

(A) I and III
(B) I and IV
(C) II and III
(D) II and IV

11. 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

12. What is the term for the electrode where oxidation occurs?

(A) anode   (B) cathode   (C) oxidizing agent   (D) reducing agent

13. 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

3

14. Identify the substance below that would be an active electrode in electrolysis.

(A) Carbon   (B) Copper   (C) Titanium   (D) Graphite

15. 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 mol = 96500 C/mol

(A) 0.002   (B) 0.02   (C) 0.2   (D) 2.0

16. 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

17. Which of the following graphs illustrates the Boltzmann distribution curve?
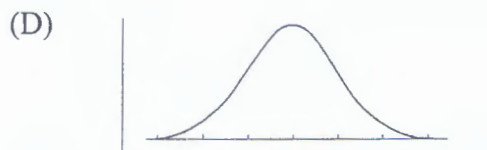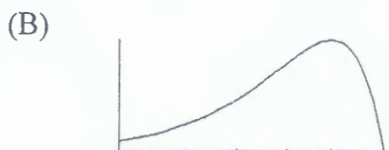
18. Which BEST describe how a catalyst works?

(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

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

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

20. The equilibrium constant for the reaction $2A + B \rightleftharpoons 3C + D$

(A) $\dfrac{[C]^3[D]}{[A]^2[B]}$ (C) $\dfrac{[2A][B]}{[3C][D]}$

(B) $\dfrac{[3C][D]}{[2A]B]}$ (D) $\dfrac{[A]^2[B]}{[C]^3[D]}$

GO ON TO THE NEXT SECTION   **Total 30 marks**

This section contains a compulsory questions.

Answer and show ALL working for full marks.

Question 1: STOICHIOMETRY

1. Liquefied petroleum gas (LPG) commonly known as cooking gas contains mainly the hydrocarbon propane C_3H_8 that has been compressed into a metal cylinder for easy storage and use. Propane is a very good fuel that burns completely in oxygen gas to produce carbon dioxide and water vapour.

    (a) Write a balanced chemical equation to show the products formed from the burning of propane gas. You must include state symbols! (3 marks)

    _____

    _____

    (b) Mark, a chemistry student, during an experiment combined 10.0 g of propane with 10.0g of oxygen at s.t.p.

    (i) Determine the limiting reactant (6 marks)

    _____

    _____

    _____

    _____

    _____

    _____

    _____

    (ii) What reactant was present in excess? Determine the mass of the reactant in excess that was left at the end of the reaction. (4 marks)

    _____

    _____

    _____

    _____

    _____

    _____

    (iii) What is the theoretical yield in grams of carbon dioxide produced? (3 marks)

    _____

    _____

    _____

    _____

_____

_____

(iv)   If 4032 cm³ of carbon dioxide were collected, determine the percent yield for the reaction.   (4 marks)

_____

_____

_____
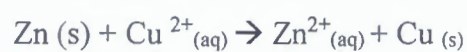
_____

_____

_____

Total 20 marks

SECTION C

This section contains Two (2) questions. Choose and answer One (1) question. Show all working for full marks.

Question 2: OXIDATION AND REDUCTION

Use the following equation to answer the questions below:

$$Zn_{(s)} + Cu^{2+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$$

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) $\underline{Cr}\,O_4^{2-}$

(b) $K\underline{Mn}O_4$

(c) $K_2\underline{Cr}O_7$

(d) $\underline{Na}$

(4 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.
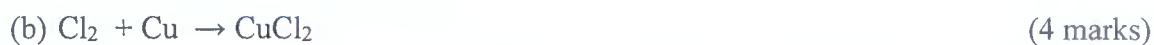
(a) $Al^{3+} + Zn \rightarrow Al + Zn^{2+}$ (4 marks)

_____

_____

_____

_____

(b) $Cl_2 + Cu \rightarrow CuCl_2$ (4 marks)

_____

_____

_____

_____

Total 20 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)

_____

_____

What ions move toward the anode and the cathode respectively?   (2 mark)

_____

_____

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

_____

_____

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

_____

_____

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

_____

_____

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

_____

_____

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

                                                                       (2 marks)

_____

_____

_____

_____

(g) Calculate
     (i)   the number of moles of copper deposited on the electrode
     (ii)   the many grams of copper deposited

                                                                       (3 marks)

_____

_____

8

_____

_____

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

Show a possible apparatus for this electrolysis process.

(5 marks)

Total 20 marks

This section contains three (3) questions.

Answer <u>TWO (2) questions.</u> 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 marks)
   -

(c) Redraw your curve on a different graph. If the temperature, T_1, was increased by 10 °C to T_2, draw a separate curve on this same graph to represent the effect of this increase in temperature. (2 marks)

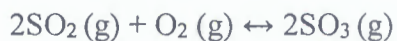(d) What effect does this increase in temperature have on the rate of the reaction? Give <u>one</u> explanation.

_____

_____

_____

_____

(2 marks)

Total 15 marks

GO ON TO THE NEXT PAGE

QUESTION 5: EQUILIBRIUM

A. The reaction

$$2SO_2 (g) + O_2 (g) \leftrightarrow 2SO_3 (g)$$

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

$$H_2 (g) + I_2 (g) \rightleftharpoons 2HI (g)$$
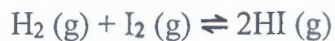
At equilibrium, the concentrations of reactants and products are:

$[H_2] = 0.20 \text{ M}$ $[I_2] = 0.50 \text{ M}$ $[HI] = 1.40 \text{ M}$

(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 the Bronsted- Lowry model, define the following

    (a) A Bronsted- Lowry acid   (1 mark)

_____

_____

    (b) A Bronsted- Lowry base   (1 mark)

_____

_____

_____

_____

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

$$HClO_4(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + ClO_4^-(aq)$$ (2 marks)
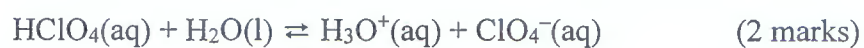
Total 15 marks

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 cm^3 of sodium hydroxide (4.0M) was added to 50 cm^3 of 4.0 M hydrochloric acid. When the reaction was complete, the temperature had risen by 10 ^{O}C.

                                                                        (2 marks)

(b) 50.6 g of sodium nitrate were dissolved in 50 cm^3 of water. The temperature fell by 16°C.

                                                                        (2 marks)

C. When 25cm^3 of 2.0 moldm^{-3} nitric acid were added to 25 cm^3 of 2.0 moldm^{-3} sodium hydroxide in a styrofoam cup, the temperature rose from 27°C to 35°C.

   $$NaOH \ (aq) + HNO_3 \ (aq \rightarrow NaNO_3 \ (aq) + H_2O \ (l)$$
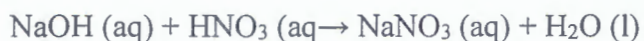
(a) How many moles of sodium hydroxide are there in 25cm^3 of 2.0 moldm^{-3} of solution?

   _____

   _____

   _____

   _____

                                                                        (2 marks)

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

   _____

   _____

14

(c) Calculate the heat given out in this reaction.
(Heat ΔH = m(mass in grams) x c x ΔT)
($1 cm^3$ of a dilute solution has a mass of 1 g. Take specific heat capacity of this solution to be $4200 Jg^{-1}K^{-1}$).

_____

_____

_____

_____

(3 marks)

(d) What is the heat of neutralization ΔH_n^e 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

Group																	
I	**II**												**III**	**IV**	**V**	**VI**	**VII**	**0**
						1.0 H hydrogen 1												4.0 He helium 2
6.9 Li lithium 3	9.0 Be beryllium 4												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												27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	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
85.5 Rb rubidium 37	87.6 Sr strontium 38	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 unununium 110	— Uuu unununium 111	— Uub ununbium 112			— Uuq ununquadium 114		— Uuh ununhexium 116		— Uuo ununoctium 118

lanthanides *	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	— 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 * *	— Th thorium 90	— Pa protactinium 91	— U uranium 92	— Np neptunium 93	— Pu plutonium 94	— Am americium 95	— Cm curium 96	— Bk berkelium 97	— Cf californium 98	— Es einsteinium 99	— Fm fermium 100	— Md mendelevium 101	— No nobelium 102	— Lw lawrencium 103