Index No:_____ **IM 06.16s**

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD
UNIVERSITY OF MALTA, MSIDA

MATRICULATION EXAMINATION
INTERMEDIATE LEVEL
SEPTEMBER 2016

SUBJECT:	CHEMISTRY
DATE:	30th August 2016
TIME:	4:00 p.m. to 7:05 p.m.

Useful information

Avogadro's constant = 6.023×10^{23}
Relative atomic masses: H = 1; C = 12; O = 16; Ca = 40.
A Periodic Table is included.

Section A
Answer ALL questions in this Section

1. The technician prepared a sample of calcium carbonate; she weighed 0.40 g of calcium carbonate.
   (a) Find the number of moles of calcium carbonate present in the sample.

_____

_____

_____

_____

(2 marks)

   (b) Calculate the number of Ca^{2+} ions present in the sample of calcium carbonate.

_____

_____

(1 mark)
Total: 3 marks

2. In radioactivity, gamma is electromagnetic radiation while alpha and beta are particles.
   (a) Give the symbol, including mass number and atomic number, of an alpha and a beta particle.

_____

(2 marks)

   (b) What element is an alpha particle?

_____

(1 mark)
Total: 3 marks

3. Consider period 3 of the Periodic Table.
   (a) Give the valency of each element, from group I to group 0 (or VIII), in period 3.

_____

_____

(3 marks)

   (b) 'Valency is a **periodic** property.' Explain briefly the term 'periodic'.

_____

_____

(1 mark)

Total: 4 marks

4. (a) Hydrogen and chlorine bond covalently together. Draw a dot-and-cross diagram of the hydrogen chloride molecule.

(1 mark)

   (b) Hydrogen and chlorine have different electronegativities. The covalent bond between hydrogen and chlorine is a **polar** bond.
      (i) Comment on the difference in electronegativity between hydrogen and chlorine.

_____

_____

(1 mark)

      (ii) Explain briefly why the covalent bond between hydrogen and chlorine is polar.

_____

_____

_____

(1 mark)

Total: 3 marks

5. Two ice cubes were placed in a glass and left on the kitchen table for two hours. The water in the glass was then placed in a pot and boiled.
   (a) Describe briefly the behaviour of the water particles in the three physical states in terms of the kinetic theory.

_____

_____

_____

_____

(3 marks)

(b) "*My brother left the perfume bottle open. I could smell the perfume from the other room.*" Explain briefly.

_____

_____

_____

(1 mark)
Total: 4 marks

6. "Benzene is an aromatic **hydrocarbon**. It has a stable **delocalised** structure."
   (a) Explain each of the terms in bold in the statement.
      (i) hydrocarbon: _____

_____

      (ii) delocalised: _____

_____

(2 marks)

   (b) (i) Benzene reacts with chlorine in the presence of a catalyst. Give the name and write the structural formula of the product of this reaction.

_____

(1 mark)

      (ii) What type of reaction is this reaction?

_____

(1 mark)
Total: 4 marks

Please turn the page.

7. (a) **Monomers** join together to form **polymers**. Explain each of the terms in bold in the statement.
   (i) monomers: _____

_____

   (ii) polymers: _____

_____

(2 marks)

   (b) (i) Give an equation showing the polymerisation reaction of ethene.

(1 mark)

   (ii) Both alkenes and difunctional molecules form polymers. Distinguish between the type of polymerisation reaction that takes place in these two cases.

_____

_____

(1 mark)

Total: 4 marks

8. A student carried out an acid-base titration. She placed the hydrochloric acid solution of unknown concentration in the burette, and 25 cm^3 of 0.12 $moldm^{-3}$ sodium hydroxide solution and a few drops of indicator in a conical flask. She repeated the titration and the results are reported in the Table below:

	Titration 1	**Titration 2**	**Titration 3**
Final burette reading (cm^3)	20.80	40.80	31.20
Initial burette reading (cm^3)	0.00	20.80	11.20
Titre value (cm^3)			

   (a) (i) Fill in the titre values in the Table above and calculate the average titre value.

_____

_____

(1 mark)

   (ii) Explain briefly your reasoning in calculating the average titre value.

_____

_____

(1 mark)

   (b) Calculate the concentration of the hydrochloric solution.

_____

_____

_____

(3 marks)

Total: 5 marks

Section B
Answer ALL questions in this Section

9. A gas occupies a volume of 0.05 m^3 at a pressure of 100,000 Pa and a temperature of 27 ^{O}C. The mass of the gas is 88 g.

(a) Assuming that the gas is an ideal gas, find the number of moles of gas present.

_____

_____

_____

_____

_____

_____

_____

_____

(3 marks)

(b) Calculate the relative molecular mass of the gas.

_____

_____

_____

_____

(2 marks)

(c) Suggest a molecular formula for the gas.

_____

(1 mark)

Total: 6 marks

Please turn the page.

10. The molecules of water, ammonia, aluminium chloride and phosphorus pentachloride are all covalently bonded.

(a) Draw the dot-and-cross diagrams (using outer shell electrons only) for each of these four molecules.

(4 marks)

(b) Aluminium chloride and phosphorus pentachloride do not satisfy the 'octet rule'. Explain briefly.

_____

_____

_____

_____

_____

_____

(2 marks)

Total: 6 marks

11. Methane, water and ammonia molecules all have four electron pairs around the central atom, but they do not have the same shape. Explain briefly.
(Apart from new diagrams in your answer, you may wish to refer to the dot-and-cross diagrams in question 10.)

Total: 6 marks

Please turn the page.

12. Consider the following reaction: A (aq) + B (s) → X (aq)

(a) Sketch two graphs: concentration of A against time, and concentration of X against time. Label the axes accordingly.

(3 marks)

(b) Reactant B is a solid, and the reaction was carried out twice as follows: (i) with 2 g of B as one block; and (ii) with 2 g of B in powder form. Assuming that the concentration of A is the same in both cases, explain the change, if any, in the rate of the reaction.

_____

_____

_____

_____

_____

_____

(2 marks)

(c) Indicate what effect on the rate of reaction would an increase in temperature and an increase in pressure have.

_____

_____

_____

(1 mark)

Total: 6 marks

13. (a) Organic compounds are classified into homologous series.

(i) There is more than one homologous series that contains hydrocarbons; one of them is the alkanes. Give the name of **two** other homologous series that contain hydrocarbons.

_____

(1 mark)

(ii) All homologous series have a general formula. Give the general formula of the alkanes.

_____

(1 mark)

(iii) Give another **two** common features of compounds in the same homologous series.

_____

_____

(1 mark)

(b) The alkane with five carbons has three isomers. Give the structural formula and the name of the three isomers.

(3 marks)

Total: 6 marks

Section C
Answer TWO questions from this Section

14. This question concerns transition elements.
    (a) Define a transition element. (1 mark)
    (b) Discuss **four** chemical properties that characterise transition elements. For each property illustrate your answer with one specific example of a transition element. (6 marks)
    (c) Give the electron configuration in terms of s, p and d orbitals of:
    (i) the Mn atom; and (ii) the Fe^{2+} ion. (Atomic numbers: Mn = 25; Fe = 26) (1 mark)
    (d) Explain why Mn^{3+} is easily reduced to Mn^{2+}, whereas Fe^{2+} is easily oxidised to Fe^{3+}. (2 marks)
    (e) Using the species $[Fe(H_2O)_6]^{2+}$ as an example, explain what is meant by the terms:
    (i) complex ion; (ii) ligand; and (iii) co-ordination number. (3 marks)
    (f) Draw a diagram to show the geometrical shape of $[Fe(H_2O)_6]^{2+}$, name the shape and describe the bonding in it. (2 marks)
    (g) Manganate(VII) ions will oxidise ethanedioate ions ($C_2O_4^{2-}$) to carbon dioxide in acidic solution. The following experiment was carried out to find the number of moles of water of crystallisation, x, in ammonium ethanedioate $(NH_4)_2C_2O_4.xH_2O$.
    A quantity, 2.13g, of hydrated ammonium ethanedioate was dissolved in dilute sulfuric(VI) acid and the volume made up to 250 cm^3 in a volumetric flask. 25cm^3 portions of this solution required 30.00 cm^3 of 0.02 $moldm^{-3}$ of potassium manganate (VII) for complete oxidation.
    (i) Write a balanced ionic half equation to show the reduction of manganate(VII) ions to Mn^{2+} ions.
    (ii) Write a balanced ionic half equation to show the oxidation of ethanedioate ions.
    (iii) Write a balanced equation that represents the redox reaction between manganate(VII) ions and ethanedioate ions.
    (iv) How many moles of manganate(VII) ions were used in the titration?
    (v) How many moles of ethanedioate ions were present in 25cm^3 of the solution?
    (vi) What mass of ammonium ethanedioate was present in the original weighed sample?
    (vii) What mass of water of crystallisation was contained in the weighed sample?
    (viii) Deduce the formula of the hydrated ammonium ethanedioate. (5 marks)

Total: 20 marks

15. In the Haber process, nitrogen and hydrogen react as shown in the equation:

$$N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g) \qquad \Delta H^o = -92\ kJmol^{-1}$$

The following Table shows the percentage yield of ammonia, under different conditions of temperature and pressure.

Pressure / Pa	10,000kPa	20,000kPa	50,000kPa
% yield at 600 K	50	60	75
% yield at 800 K	10	16	25
% yield at 1000 K	2	4	7

    (a) Referring to the given Haber process reaction, explain the meaning of the term dynamic equilibrium. (1 mark)
    (b) State Le Chatelier's principle. (2 marks)
    (c) The above table shows that 75 % yield of ammonia is obtained at a pressure of 50,000 kPa and a temperature of 600 K. Explain how Le Chatelier's principle predicts that such conditions give a high conversion to ammonia. (3 marks)

(d) Many industrial ammonia plants operate under compromise conditions of temperature and pressure and make use of a catalyst.
   (i) Name the catalyst used in the process.
   (ii) From the above Table identify an appropriate set of compromise conditions and explain, in detail, why compromise conditions of pressure and temperature and a catalyst are used. (7 marks)

(e) Sketch an appropriate energy profile diagram for the non-catalysed and catalysed production of ammonia. In your diagram label the axes, and mark the activation energy and the enthalpy change of the reaction. (3 marks)

(f) Explain how a catalyst affects the activation energy of a reaction and describe how the catalyst in the Haber Process functions as a heterogeneous catalyst. (4 marks)

Total: 20 marks

16. Some bond energy terms are listed below:

Bond	H – H	C – H	C – Br	C – C	C = C	Br – Br
Bond energy / $kJmol^{-1}$	435	415	284	356	598	193

(a) Define *bond energy term*. (1 mark)

(b) Using the given data, calculate the enthalpies of formation from gaseous atoms of: (i) gaseous propene; and (ii) gaseous 1,2-dibromopropane. (4 marks)

(c) Using bond energy terms, compare the above enthalpy changes of formation in terms of exothermicity or endothermicity and explain why the enthalpy changes of the above reactions are different. (3 marks)

(d) Calculate the enthalpy change (ΔH^o) for the bromination of propene. (4 marks)

(e) The bromination of propene takes place in the presence of an inert solvent, as carbon tetrachloride. Name and show the mechanism involved in the bromination of propene. (4 marks)

(f) List and explain **four** differences between the brominations of propene and propane. (4 marks)

Total: 20 marks

17. (a) The melting point of the elements in Periods 2 and 3 of the Periodic Table is a periodic property.
   (i) Sketch a graph of melting point against atomic number to show the trends in the melting points of the elements in Period 2. (3 marks)
   (ii) Referring to each element in Period 2 and the sketch in (a)(i), explain what determines the melting point of an element and why the melting points of the elements in Period 2 vary. (5 marks)

(b) X and Z are Period 2 elements. Both elements form oxides when they burn in oxygen. Element X forms an oxide of formula X_2O, which is a crystalline solid, is soluble in water and has a high melting point. When melted X_2O readily conducts electricity. The oxide of element Z has the formula ZO_2, and is a gas at room temperature. ZO_2 is moderately soluble in water giving a weakly acidic solution. In an experiment, *gaseous* ZO_2 is bubbled into an aqueous solution of Z_2O.
   (i) Identify elements X and Z and discuss, using diagrams, the type of bonding present in elements X and Z. (4 marks)
   (ii) Using the above information, discuss the type of bonding present in the oxides X_2O and ZO_2. Draw diagrams to clarify your answer. (4 marks)
   (iii) Write balanced equations, including state symbols, to represent the reactions of the oxides of X and Z with water. (2 marks)
   (iv) Write a balanced equation, including state symbols, for the reaction that occurs when ZO_2 is bubbled into an aqueous solution of X_2O. (2 marks)

Total: 20 marks

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PERIODIC TABLE

I	II											III	IV	V	VI	VII	VIII
1 **H** 1																	4 **He** 2
7 **Li** 3	9 **Be** 4											11 **B** 5	12 **C** 6	14 **N** 7	16 **O** 8	19 **F** 9	20 **Ne** 10
23 **Na** 11	24 **Mg** 12											27 **Al** 13	28 **Si** 14	31 **P** 15	32 **S** 16	35.5 **Cl** 17	40 **Ar** 18
39 **K** 19	40 **Ca** 20	45 **Sc** 21	48 **Ti** 22	51 **V** 23	52 **Cr** 24	55 **Mn** 25	56 **Fe** 26	59 **Co** 27	59 **Ni** 28	63.5 **Cu** 29	65 **Zn** 30	70 **Ga** 31	73 **Ge** 32	75 **As** 33	79 **Se** 34	80 **Br** 35	84 **Kr** 36
85 **Rb** 37	88 **Sr** 38	89 **Y** 39	91 **Zr** 40	93 **Nb** 41	96 **Mo** 42	99 **Tc** 43	101 **Ru** 44	103 **Rh** 45	106 **Pd** 46	108 **Ag** 47	112 **Cd** 48	115 **In** 49	119 **Sn** 50	122 **Sb** 51	128 **Te** 52	127 **I** 53	131 **Xe** 54
133 **Cs** 55	137 **Ba** 56	139 **La** 57	178.5 **Hf** 72	181 **Ta** 73	184 **W** 74	186 **Re** 75	190 **Os** 76	192 **Ir** 77	195 **Pt** 78	197 **Au** 79	201 **Hg** 80	204 **Tl** 81	207 **Pb** 82	209 **Bi** 83	209 **Po** 84	210 **At** 85	222 **Rn** 86
223 **Fr** 87	226 **Ra** 88	227 **Ac** 89															

Key

Relative atomic mass — A, X, Z — *Atomic Number*

140 **Ce** 58	141 **Pr** 59	144 **Nd** 60	147 **Pm** 61	150 **Sm** 62	152 **Eu** 63	157 **Gd** 64	159 **Tb** 65	162 **Dy** 66	165 **Ho** 67	167 **Er** 68	169 **Tm** 69	173 **Yb** 70	175 **Lu** 71
232 **Th** 90	231 **Pa** 91	238 **U** 92	237 **Np** 93	244 **Pu** 94	243 **Am** 95	247 **Cm** 96	247 **Bk** 97	251 **Cf** 98	252 **Es** 99	257 **Fm** 100	258 **Md** 101	259 **No** 102	260 **Lr** 103