Index Number:_____ IM06.18s

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

INTERMEDIATE MATRICULATION LEVEL
2018 SECOND SESSION

SUBJECT:	**Chemistry**
DATE:	6th September 2018
TIME:	9:00 a.m. to 12:05 p.m.

Useful information

Relative atomic masses: C = 12, O = 16
Avogadro constant = 6×10^{23}
Molar gas constant = 8.31 $Jmol^{-1}K^{-1}$
A Periodic Table is included.

SECTION A

Answer ALL questions in this section.

1. (a) Gamma radiation is a type of electromagnetic radiation, while alpha and beta are particles. Write the symbols for both alpha and beta, indicating the mass number and the atomic number in each case.

Alpha: _____(½) Beta: _____ (½)

(b) Name **ONE** radioisotope that is used in medicine or in industry, and describe its use.

_____

_____

_____

_____ (2)

(Total: 3 marks)

2. (a) A sample of carbon dioxide at a temperature of 0 ^{O}C and a pressure of 1 atmosphere has a mass of 22 g. Find the number of moles of carbon dioxide that are present in the sample.

_____

_____

_____ (2)

(b) Find the number of particles present in the sample of carbon dioxide.

_____

_____ (1)

(Total: 3 marks)

3. (a) Sketch a graph showing the distribution of molecular kinetic energies with temperature (on the x-axis).

(2)

(b) Explain what happens to the plot if it is recorded at a higher temperature. Sketch the graph at the higher temperature T_2 on the same axes used for part (a).

(2)

(Total: 4 marks)

4. Consider period 2 of the Periodic Table, the elements lithium to neon. Comment on the variation of the following properties of the elements across the period:
(a) valency;

(1)

(b) first ionisation energy.

(3)

(Total: 4 marks)

5. This question concerns the coordination compounds $[Fe(H_2O)_6]^{2+}$ and $[Cu(NH_3)_4]^{2+}$.

(a) Explain the following two terms, using the above two coordination compounds as examples to illustrate your answer:

(i) ligand;

_____

_____ (1)

(ii) coordination number.

_____

_____ (1)

(b) Indicate the molecular shape of $[Fe(H_2O)_6]^{2+}$ and $[Cu(NH_3)_4]^{2+}$. Use diagrams to illustrate your answer.

$[Fe(H_2O)_6]^{2+}$: _____(1) $[Cu(NH_3)_4]^{2+}$: _____ (1)

(Total: 4 marks)

6. (a) The type of bonding in metals is called 'metallic bonding'. Explain briefly the term metallic bonding.

(1)

(b) Explain each of the following statements in terms of structure and physical properties:
(i) metals are good conductors of electricity;

(1)

(ii) in general, there are substances that are soluble in polar solvents while others are soluble in non-polar solvents.

(2)

(Total: 4 marks)

7. (a) Consider the following combustion reaction:

$$C(graphite) + O_2(g) \rightarrow CO_2(g) \quad \Delta H° = -394 \text{ kJmol}^{-1}$$

How many grammes of carbon (graphite) must be (completely) burnt in oxygen in order to get 197 kJ of energy released?

(2)

(b) Consider the following neutralisation reaction:

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l) \quad \Delta H° = -394 \text{ kJmol}^{-1}$$

A volume of 100 mL of 0.1 moldm^{-3} hydrochloric acid solution was totally neutralised with an excess volume, 110 mL, of 0.1 moldm^{-3} sodium hydroxide solution, to assure that all the hydrochloric acid reacted. How much energy, in kJ, was released?

(2)

(Total: 4 marks)

8. Consider the following reactions to identify the anions in each case. Fill in the blanks in the tables below.

Addition of silver nitrate solution dropwise, observe, and then add excess	**Precipitate**	**Identified anion**
White precipitate, turning grey on standing in bright light; insoluble in dil. HNO_3	***AgCl precipitated***	***This indicates Cl^-***
Cream precipitate, sometimes also yellow		

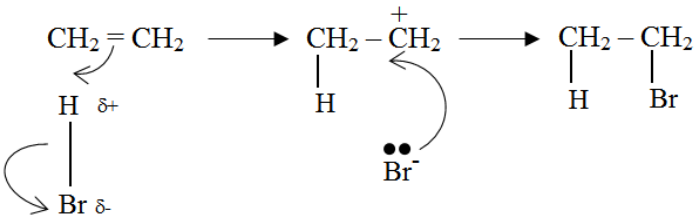
(1)

Addition of a little dilute hydrochloric acid solution	**Test for gases evolved**	**Identified anion**
Very pungent gas evolved, turning damp dichromate paper green	Gas evolved =	(1)
Very pungent gas evolved, turning damp dichromate paper green, fine precipitate	Fine precipitate =	(2)

(Total: 4 marks)

SECTION B
Answer ALL questions in this section.

9. (a) The mechanism of the reaction between ethene and HBr can be summarised as follows:



(i) Write the separate steps of the reaction mechanism using equations.

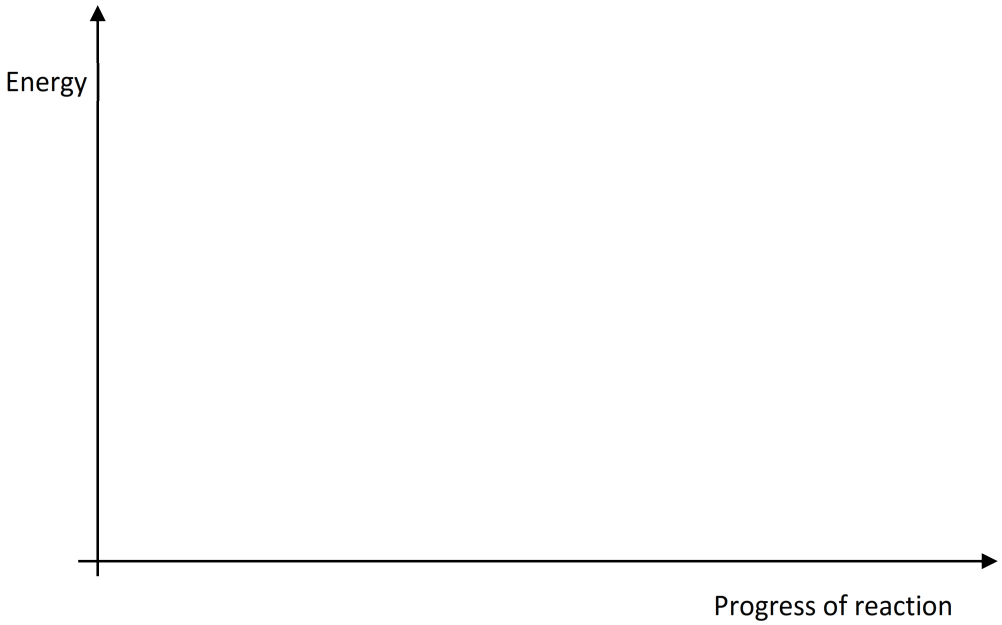
(2)

(ii) Indicate which of the two steps is the rate determining step, giving reasons for your answer.

(1)

This question continues on the next page.

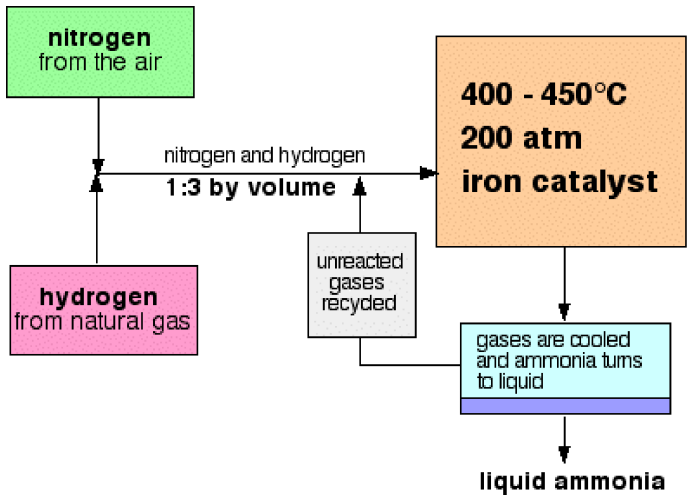
(b) By using a reaction profile diagram, and using the same set of axes below, distinguish between a catalysed and an uncatalysed reaction. Explain your answer.



(3)

(Total: 6 marks)

10. (a) The following flow scheme summarises the Haber preocess.



https://www.chemguide.co.uk/physical/equilibria/haber.html

(i) Write the equation, including state symbols, that represents this reversible reaction.

(1)

(ii) Write the equation for K_p for this reversible reaction, and the corresponding units for K_p.

(1)

(b) (i) "The pressure: The pressure varies from one manufacturing plant to another, but is always high. You can't go far wrong … quoting 200 atmospheres. …"

https://www.chemguide.co.uk/physical/equilibria/haber.html

Explain in terms of Le Chatelier's principle.

(2)

(ii) "The temperature: … In order to get as much ammonia as possible in the equilibrium mixture, you need as low a temperature as possible. However, 400-450 °C isn't a low temperature! … 400-450 °C is a compromise temperature …"

https://www.chemguide.co.uk/physical/equilibria/haber.html

Explain in terms of Le Chatelier's principle, considering that the forward reaction (the production of ammonia) is exothermic, and also the "compromise temperature" argument.

(2)

(Total: 6 marks)

Please turn the page.

11. (a) A sample of liquid ethanol was heated above its boiling point (78.4 ^{O}C). The volume of the resulting vapour was 50 mL at a pressure of 101,000 Pa and a temperature of 127 ^{O}C.

(i) Find the number of moles of ethanol present.

(3)

(ii) Find the mass of the sample of ethanol.

(1)

(b) Suggest a simple chemical test for the presence of ethanol. Outline the procedure, including the equation.

(2)

(Total: 6 marks)

12. Iodine can be partitioned by solvent extraction using water and carbon tetrachloride.

(a) Outline the process that needs to be carried out for such an extraction. Indicate clearly the apparatus that needs to be used and draw a diagram of it in the space below.

(4)

(b) Iodine is a non–polar substance. Explain how it will be partitioned between the non–polar organic solvent and the highly polar water solvent.

(2)

(Total: 6 marks)

13. Alkanes, alkenes and alkynes are hydrocarbons.

(a) Explain the term hydrocarbons.

(1)

(b) Propene undergoes an addition reaction with hydrogen bromide. Predict the most abundant product. Explain your answer.

(3)

(c) Alkenes can be prepared by the dehydration of an alcohol. Explain.

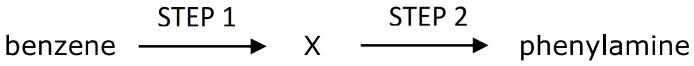
(2)

(Total: 6 marks)

SECTION C

Answer any TWO questions from this section. Write your answers on the lined pages of this booklet.

14. (a) This question is about the synthesis of phenylamine, starting from benzene.



(i) Draw the structure of the benzene molecule and explain the bonding between the carbon atoms in the benzene molecule. (3)
(ii) Compound X can be synthesised from benzene and can form phenylamine. Name and draw the structure of compound X. (1)
(iii) Name the reagents and state the conditions which are required for STEP 1. (2)
(iv) Name the reagent/s and conditions which are required in STEP 2. (2)
(v) Name the types of reaction which occur in STEP 1 and in STEP 2. (1)

(b) Compound A is a three-carbon organic compound with one functional group. It can be converted through separate synthetic routes to other compounds. In one route, A is reduced to B which is then dehydrated to C. Both B and C have three carbon atoms. C decolourises bromine liquid in both dark and light conditions. In another route, compound A reacts with sodium cyanide in acid to form D. D is hydrolysed with dilute acid to form E.

Both compounds B and E react with phosphorus pentachloride. One mole of B requires one mole of phosphorus pentachloride, whereas one mole of E requires two moles of phosphorus pentachloride.
(i) Name compounds A, B and C. (3)
(ii) Name the reagents and state the conditions which are required to convert A to B. (1)
(iii) Name the reagents and state the conditions which are required to convert B to C. (1)
(iv) Write a balanced equation which represents the reaction of C with bromine liquid. (1)
(v) Draw the chemical structures of compounds D and E. (2)
(vi) Explain why compound B requires one mole of phosphorus pentachloride, but one mole of compound E requires two moles of phosphorus pentachloride. (2)
(vii) Describe a test, which is not mentioned above and which you would use to confirm the class identity of compound A. (1)

(Total: 20 marks)

15. This question concerns the chemistry of ammonia.
(a) In the Haber Process, ammonia is removed from a mixture of ammonia, nitrogen and hydrogen gases. The following table gives the boiling points of the three gases at atmospheric pressure.

Gas	NH_3	N_2	H_2
Boiling point in ^oC	-33	-196	-253

(i) Use the above data to explain how ammonia can be removed from the mixture of gases at atmospheric pressure. (2)
(ii) Give reasons for the variation in the boiling point of the above three substances ammonia, nitrogen and hydrogen. (2)

(b) Ammonia is a volatile ingredient found in several household cleaning products. An analyst was asked to determine the concentration of ammonia in a new brand of household cleaning products.
25 cm^3 of the cleaning liquid was pipetted into a 250 cm^3 volumetric flask. Water was added to the 250 cm^3 mark of the volumetric flask to dilute the solution. 25 cm^3 portions of this diluted solution were each pipetted into four conical flasks and each portion was quickly mixed with 50 cm^3 of 0.01 $moldm^{-3}$ hydrochloric acid. The excess hydrochloric acid in each conical flask was titrated with 0.005 $moldm^{-3}$ sodium carbonate solution. The following four titre values were obtained: 21.65 cm^3, 21.50 cm^3, 21.45 cm^3, 21.50 cm^3.

(i) Write a balanced chemical equation for the reaction of sodium carbonate and hydrochloric acid. (2)

(ii) Calculate the number of moles of hydrochloric acid which reacted with sodium carbonate. (4)

(iii) Calculate the number of moles of hydrochloric acid mixed with the diluted ammonia. (2)

(iv) Write an equation for the reaction of ammonia with hydrochloric acid. (2)

(v) Calculate the number of moles of ammonia in 25 cm^3 of the diluted mixture. (2)

(vi) Calculate the concentration of ammonia in the new brand of the cleaning product. (4)

(Total: 20 marks)

16. (a) (i) Write the oxidation number of the chlorine atom in: Cl_2, ClO^-, ClO_3^-, ClO_4^-. (2)

(ii) Chlorine reacts with water to form hydrochloric acid and chloric (I) acid (HOCl). Discuss why chlorine is a bleaching agent in the presence of water. (2)

(iii) When chlorine reacts with hot concentrated potassium hydroxide, it disproportionates according to the following equation.

$$3Cl_2(g) + 2OH^-(aq) \rightarrow 5Cl^-(aq) + ClO_3^-(aq) + 3H_2O(l)$$

Use the above reaction to explain the term disproportionation. (2)

(iv) When $KClO_3$ is heated to just above its melting point, it forms KCl and $KClO_4$. Write a balanced ionic equation for this reaction. (2)

(b) It is possible to predict the relative reactivity of metals from their position in the electrochemical series.

(i) Arrange the following elements in order of their reducing power, starting from the strongest reducer: Cu, K, Zn, Mg. (2)

(ii) Describe what you observe in the following two experiments:
- when granulated zinc is added to a solution of copper sulphate (VI); and
- when small pieces of copper are added to a solution of zinc sulphate (VI). (3)

(iii) Write a balanced equation with state symbols for a reaction which occurs in part (ii). (1)

(c) A piece of copper alloy, weighing 3 g, was treated with reagents to form a solution of copper(II) ions. Water was added to make up 250 cm^3 of solution. 25 cm^3 of this solution was added to an excess of potassium iodide solution.

$$2Cu^{2+}(aq) + 4I^-(aq) \rightarrow 2CuI(s) + I_2(aq)$$

The iodine which was formed in this reaction required 40 cm^3 of 0.100 $moldm^{-3}$ sodium thiosulfate solution in a titration. The equation for this reaction is:

$$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$$

(i) Calculate the number of moles of thiosulfate ions which reacted with iodine in the above reaction. (1)

(ii) Calculate the number of moles of iodine which were formed in the reaction of copper ions and excess potassium iodide. (1)

(iii) What mass of copper was present in the alloy sample? (3)

(iv) What is the percentage of copper in the copper-based alloy? (1)

(Total: 20 marks)

Please turn the page.

17. (a) According to the Bronsted-Lowry theory, water can function as an acid and as a base.
    (i) Use the reactions of water with (I) hydrogen chloride gas, and with (II) ammonia gas to explain the above statement. (3)
    (ii) Write an expression for the ionic product for water K_w. (1)
    (iii) The ionic product for water has a value of 1.00×10^{-14} mol^2dm^{-6} at 25 ^oC. Use this information to show why the pH of pure water is 7 at 25 ^oC. (2)
    (iv) At 35 ^oC, K_w has a value of 2.916×10^{-14} mol^2dm^{-6}. Calculate the pH of pure water at this temperature. (2)
    (v) Is the water at 35 ^oC acidic, alkaline or neutral? Explain your answer. (1)
    (vi) What is the pH of a solution of sodium hydroxide of concentration 0.010 $moldm^{-3}$ at 25 ^oC? (3)

    (b) (i) Write an equation showing the reaction which occurs when methanoic acid dissolves in water. (1)
    (ii) Write an expression for K_a for methanoic acid and give the units of K_a. (2)
    (iii) The values of K_a for methanoic acid and ethanoic acid are 1.6×10^{-4} and 1.7×10^{-5} respectively (units as in part (b)(ii) in both cases). Which one is the weaker acid? Explain your answer. (2)
    (iv) Five pH labels of 9, 7, 2.37, 1 and 0.82 were properly fixed on five sample bottles containing solutions of known pH. Which label was fixed on the bottle containing 0.100 $moldm^{-3}$ methanoic acid? Explain your answer. (3)

(Total: 20 marks)

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PERIODIC TABLE

I	II											III	IV	V	VI	VII	VIII
																	4 **He** 2
1 **H** 1																	
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