

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD  
UNIVERSITY OF MALTA, MSIDA  
MATRICULATION EXAMINATION  
INTERMEDIATE LEVEL  
MAY 2013

<b>SUBJECT:</b>	CHEMISTRY
<b>DATE:</b>	3rd May 2013
<b>TIME:</b>	9.00 a.m. to 12.00 noon

*Useful information:* One mole of any gas or vapour occupies  $22.4 \text{ dm}^3$  at s.t.p.  
The molar gas constant  $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$ .  
Relative atomic masses: H = 1, C = 12, O = 16, Cl = 35.5, K = 39, Cr = 52.

**A Periodic Table is included.**

*Section A*  
**Answer all questions in this Section**

1. Fill in the blanks in the following table.

Isotope	Number of protons	Number of neutrons	Mass number	Atomic number
${}^{35}_{17}\text{Cl}$				
${}^{52}_{24}\text{Cr}$				

(8 marks)

2. Write down the electronic configuration in spdf notation for the following elements and ions.

	Electronic configuration
${}^{35}_{17}\text{Cl}$	
${}^{52}_{24}\text{Cr}$	
$\text{Cl}^-$	

(5 marks)

3. Draw the dot-and-cross diagram for the molecules indicated in the table below. Show the outermost electron shells only.

HCl	
H <sub>2</sub> O	
CO <sub>2</sub>	

(6 marks)

4. Indicate the pH of the following liquids as equal, higher or lower than 7.

(i)	a soft drink	
(ii)	pure water	
(iii)	dilute hydrochloric acid solution	
(iv)	ammonia solution	

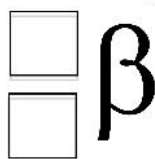
(4 marks)

5. While browsing on the net, a student found the following passage:

*“Iodine-131 ( $^{131}_{53}\text{I}$ ), also called radioiodine is an important radioisotope of iodine. It has a radioactive decay half-life of about eight days. It is associated with medical diagnostic and treatment procedures. Due to its mode of beta decay . . .”*

Complete the following statements:

- (i) The numbers in the symbol for a beta particle are:



- (ii) The beta particle is actually a high speed sub-atomic particle, that is known as the \_\_\_\_\_.

- (iii) The nuclear equation indicating the beta decay of iodine-131 is as follows:  
\_\_\_\_\_.

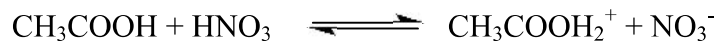
- (iv) The element that results from the decay of the iodine-131 is \_\_\_\_\_.

- (v) Assuming that the original amount of iodine-131 is 24g and its half-life is 8 days, there would be 3g of radioisotope left after \_\_\_\_\_ days.

(7 marks)

6. (i) According to the Bronsted-Lowry theory, an acid is defined as a proton \_\_\_\_\_ and a base is defined as a proton \_\_\_\_\_.

- (ii) Identify the acid, the base, the conjugate acid and the conjugate base for the following reaction:



CH <sub>3</sub> COOH	
HNO <sub>3</sub>	
CH <sub>3</sub> COOH <sub>2</sub> <sup>+</sup>	
NO <sub>3</sub> <sup>-</sup>	

(6 marks)

7. Identify the intermolecular forces present in each of the following cases:

HCl(g)	
O <sub>2</sub> (g)	
CO <sub>2</sub> (g)	
H <sub>2</sub> O(l)	

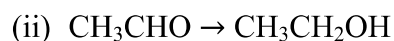
(4 marks)

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8. (a) Consider the following reactions.



A suitable reagent for this conversion is: \_\_\_\_\_.



A suitable reagent for this conversion is: \_\_\_\_\_.

(b) Complete the following equations:



(6 marks)

9. Consider the following chemical reaction:  $\text{X}_2 + 3\text{Y}_2 \rightarrow 2\text{XY}_3$ .

(i) Starting with 0.25 moles of  $\text{X}_2$  and sufficient  $\text{Y}_2$  to react with it, the number of moles of  $\text{XY}_3$  produced are \_\_\_\_\_.

(ii) The number of moles of  $\text{Y}_2$  that reacts with 0.25 moles of  $\text{X}_2$  are \_\_\_\_\_.

(iii) Starting with 0.25 moles of  $\text{X}_2$ , and given that the initial amount of  $\text{Y}_2$  is 2 moles, the number of moles of  $\text{Y}_2$  that would be left after all the  $\text{X}_2$  reacts are \_\_\_\_\_.

(5 marks)

10. Fill in the blanks in the following statements.

(i) Benzene reacts with a *nitrating mixture* to give nitrobenzene and water. The nitrating mixture is composed of: \_\_\_\_\_ and \_\_\_\_\_.

(ii) Benzene undergoes substitution to give chlorobenzene. A catalyst needed for the reaction to occur is \_\_\_\_\_. The other product of the reaction is \_\_\_\_\_.

(4 marks)

11. Fill in the blanks in the following statements.

- (i) Metallic bonding can be described as an assembly of \_\_\_\_\_ ions in a sea of \_\_\_\_\_.
- (ii) The formula of an ionic compound is the simplest ratio of ions present in the crystal or the \_\_\_\_\_ formula.
- (iii) When a metal and a non-metal react, the bonding in the compound that is formed is \_\_\_\_\_.
- (iv) When two non-metals react, the bonding in the compound that is formed is \_\_\_\_\_.

(5 marks)

12. Match the following statements with:  $\text{NH}_4^+$ ,  $\text{BF}_3$ ,  $\text{CO}_2$ ,  $\text{PCl}_5$ ,  $\text{N}_2$ . Each can be used once, more than once or not at all.

	contains a triple covalent bond
	contains single covalent bonds only
	contains a dative covalent bond
	is an electron-deficient compound
	contains an atom with an octet expansion

(5 marks)

13. Organic compounds are grouped into a number of **homologous series**. Considering a number of characteristics of a homologous series, indicate whether the term *same* or *similar* applies in each case.

General formula	
Functional group	
Chemical properties	

(3 marks)

14. Indicate the valency of each element in the following compounds.

Compound	Valencies			
MgCl <sub>2</sub>	The valency of Mg is:		The valency of Cl is:	
Al <sub>2</sub> O <sub>3</sub>	The valency of Al is:		The valency of O is:	
F <sub>2</sub> O	The valency of F is:		The valency of O is:	

(6 marks)

15. Complete the following table regarding the **structure** and the **acid-base** character of the oxides of the elements from sodium to chlorine. Some responses have already been included.

**Indicate acidic by A, basic by B and amphoteric by AM.**

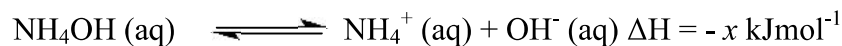
GROUP	I	II	III	IV	V	VI	VII
COMPOUND	Na <sub>2</sub> O	MgO	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	P <sub>2</sub> O <sub>3</sub>	SO <sub>2</sub>	Cl <sub>2</sub> O
STRUCTURE					<b>simple covalent molecules</b>		
ACID-BASE CHARACTER		<b>B</b>	<b>AM</b>	<b>A</b>			

(6 marks)

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*Section B***Answer all questions in this Section**

16. Consider the following equilibrium:



Under a given set of conditions, the reaction will reach a state of **dynamic equilibrium**.

(a) Explain briefly the term **dynamic equilibrium**.

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(4 marks)

(b) (i) Write the expression for the equilibrium constant  $K_C$  for the given equilibrium.

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(2 marks)

(ii) State the units of  $K_C$  for this equilibrium.

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(1 mark)

(c) Given that the numerical value of  $K_C$  at 25°C is  $1.8 \times 10^{-5}$ , calculate the equilibrium concentration of hydroxide ions if the equilibrium concentrations of the other chemical species involved are:

Concentration of  $\text{NH}_4\text{OH}$  at equilibrium =  $5.0 \times 10^{-6} \text{ mol dm}^{-3}$

Concentration of  $\text{NH}_4^+$  at equilibrium =  $0.9 \text{ mol dm}^{-3}$

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(4 marks)

(d) Explain briefly what will happen to the **position of equilibrium** and the value of  $K_C$  if after equilibrium is reached:

(i) the concentration of  $\text{OH}^-$  ion is decreased;

(2 marks)

(ii) the temperature is increased.

(3 marks)

*Total: 16 marks*

17. This question deals with the following molecules and ions:  $\text{CH}_4$ ,  $\text{NH}_3$ ,  $\text{H}_2\text{O}$  and  $\text{H}_3\text{O}^+$ . In each of these four cases there are four electron pairs around the central atom.

Fill in the table below as follows: draw the shape of the molecule/ion for each case, write the name of the shape in each of the four cases, and indicate whether each of the three molecules is polar or non-polar.

	Draw the shape	Name the shape	Polar or non-polar
$\text{CH}_4$			
$\text{NH}_3$			
$\text{H}_2\text{O}$			
$\text{H}_3\text{O}^+$			

*Total: 16 marks*



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18. (a) Considering three specific homologous series, namely alcohols, aldehydes and carboxylic acids, give their general formula and functional group.

(i) general formula – alcohols: \_\_\_\_\_

(ii) functional group – alcohols: \_\_\_\_\_

(iii) general formula – carboxylic acids: \_\_\_\_\_

(iv) functional group – carboxylic acids: \_\_\_\_\_

(v) general formula – aldehydes: \_\_\_\_\_

(vi) functional group – aldehydes: \_\_\_\_\_

(6 marks)

(b) Alcohols can be classified as primary, secondary and tertiary alcohols. Distinguish between the three classes of alcohols, illustrating your answer with an example in each case.

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(6 marks)

(c) Alcohols react with carboxylic acids to give esters.

(i) Write the equation for the reaction, including state symbols, between ethanol and ethanoic acid.

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(3 marks)

(ii) Write the name of the ester produced in the reaction described in (c)(i).

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(1 mark)

*Total: 16 marks*

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19. Explain briefly each of the following statements:

(i) The Periodic Table is composed of groups and periods.

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(4 marks)

(ii) Elements in the same group have similar chemical properties.

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(4 marks)

(iii) Metallic character changes as we go down a group.

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(4 marks)

(iv) Metallic character changes as we go across a period.

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(4 marks)

*Total: 16 marks*

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20. A sample of gas X has a mass of 0.66 g and occupies a volume of 370 cm<sup>3</sup> at a pressure of 101,325 Pa and a temperature of 27°C.

(i) Convert the value of the volume of the gas, i.e. 370 cm<sup>3</sup>, into m<sup>3</sup>.

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(2 marks)

(ii) Calculate the number of moles present in the sample of gas X. Give your answer to three decimal places.

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(6 marks)

(iii) Calculate the relative molecular mass of the gas X.

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(2 marks)

(iv) This relative molecular mass fits two gaseous compounds: an oxide of carbon and an alkane. Suggest the formulae of these two compounds.

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(4 marks)

(v) Indicate a simple chemical test to verify the gas present.

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(2 marks)

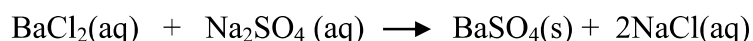
*Total: 16 marks*

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*Section C***Answer TWO questions from this Section****Write your answers on the lined pages provided.**

21. This question is about separation and purification techniques used in the laboratory.

(a) A sample of barium sulfate ( $\text{BaSO}_4$ ) is formed by means of the following reaction:



Describe how a purified sample of solid barium sulfate may be collected in the laboratory. In your description, give experimental details, the name of the technique and a labelled diagram of the apparatus. Explain, with reference to the physical properties of barium sulfate, why this is a suitable method. (10 marks)

(b) A sample of calcium chloride ( $\text{CaCl}_2$ ) is formed by means of the following reaction:



Describe how a purified sample of solid calcium chloride may be collected in the laboratory. In your description, give experimental details, the name of the technique and a labelled diagram of the apparatus. Explain, with reference to the physical properties of calcium chloride, why this is a suitable method. (10 marks)

(c) Describe how a sample of purified water may be collected from a sample of sea water in the laboratory. In your answer include the name of the technique, a labelled diagram of the apparatus as well as all the necessary details required to carry out the separation. Explain, with reference to the physical properties of the substances present, why this is a suitable method. (10 marks)

(d) Iodine may be obtained from an aqueous solution using an organic solvent such as ethoxyethane (ether). Describe how a purified sample of iodine may be collected in the laboratory. In your description, give experimental details, the name of the technique and a labelled diagram of the apparatus. Explain, with reference to the physical properties of the substances involved, why this is a suitable method. (10 marks)

*Total: 40 marks*

22. (a) (i) Define standard enthalpy of combustion. (2 marks)
- (ii) Give a chemical equation to represent the enthalpy of combustion of octane,  $C_8H_{18}$ . (4 marks)
- (iii) Define standard enthalpy of formation. (2 marks)
- (iv) Give a chemical equation to represent the enthalpy of formation of octane. (4 marks)
- (v) The enthalpy of combustion of liquid octane measured at 298K is  $-5512 \text{ kJmol}^{-1}$ . With the help of a cycle, find the enthalpy of formation of octane given that the enthalpy of combustion of carbon is  $-393.5 \text{ kJmol}^{-1}$  and the enthalpy of combustion of hydrogen is  $-285.8 \text{ kJmol}^{-1}$ . (11 marks)
- (vi) Name and state the law used in calculating the enthalpy of formation of octane in part (a)(v). (4 marks)
- (b) (i) Draw the structural formula of octane, oxygen, carbon dioxide and water. (5 marks)
- (ii) Use the structures drawn in (b)(i) and the bond enthalpy terms given below to find a value for the enthalpy of combustion of gaseous octane.

Bond enthalpy terms in  $\text{kJmol}^{-1}$ :

C-C = 348

C-H = 412

O=O = 496

C=O = 743

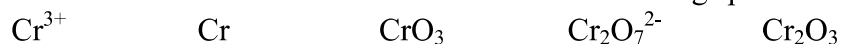
H-O = 463

(8 marks)

*Total: 40 marks*

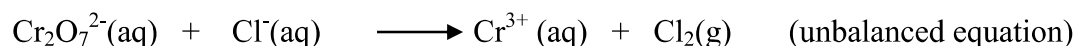
*Please turn the page.*

23. (a) Find the oxidation number of chromium in the following species:



(5 marks)

(b) The dichromate ion,  $\text{Cr}_2\text{O}_7^{2-}$ , reacts with the chloride ion,  $\text{Cl}^-$ , under acidic conditions as follows:



(i) Give a half equation for the conversion of  $\text{Cr}_2\text{O}_7^{2-}$  to  $\text{Cr}^{3+}$ . State whether this conversion represents an oxidation or a reduction, giving a reason for your answer. (5 marks)

(ii) Give a half equation for the conversion of  $\text{Cl}^-$  to  $\text{Cl}_2$ . State whether this conversion represents an oxidation or a reduction, giving a reason for your answer. (4 marks)

(iii) Combine the two half equations to form a complete balanced redox equation for the reaction of dichromate with chloride. Identify the oxidizing agent and the reducing agent in this reaction. (5 marks)

(c) In an experiment, 5.88 g of potassium dichromate,  $\text{K}_2\text{Cr}_2\text{O}_7$ , were used to prepare 250  $\text{cm}^3$  of solution.

(i) Calculate the concentration in  $\text{mol dm}^{-3}$  of the  $\text{K}_2\text{Cr}_2\text{O}_7$  solution prepared in this experiment. (4 marks)

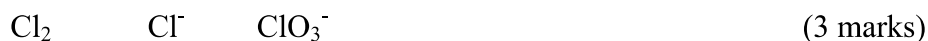
(ii) Exactly 25.0  $\text{cm}^3$  of the  $\text{K}_2\text{Cr}_2\text{O}_7$  solution were reacted with excess  $\text{Cl}^-$  ions. What mass of chlorine will be formed? (5 marks)

(iii) What volume of chlorine gas measured at 25°C and  $1.01 \times 10^5$  Pa would this reaction be expected to produce? (5 marks)

(d) In another reaction, chlorine reacts with hot concentrated sodium hydroxide according to the following equation:



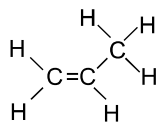
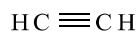
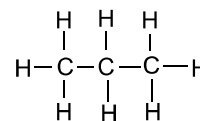
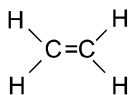
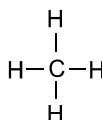
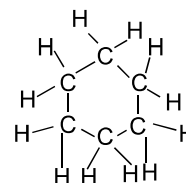
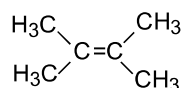
(i) Find the oxidation number of chlorine in:



(ii) Use these oxidation numbers to describe the type of reaction taking place. Explain your answer. (4 marks)

*Total: 40 marks*

24. The compounds **A** to **G** listed below are examples of *hydrocarbons*.

**A****B****C****D****E****F****G**

- (a) (i) Explain the term *hydrocarbons*. (1 mark)  
 (ii) Name the compounds **A** to **G**. (8 marks)  
 (iii) Identify two isomers from compounds **A** to **G** and describe a simple test that may be used to distinguish between samples of the two compounds. (4 marks)
- (b) Compound **A** and compound **E** react with chlorine under different conditions.
- (i) State the condition/s required for compound **A** to react with chlorine. (1 mark)  
 (ii) Give an equation for the reaction of compound **A** with chlorine. (2 marks)  
 (iii) Give the mechanism for the reaction of compound **A** with chlorine. (6 marks)  
 (iv) Explain why the structure of compound **A** enables it to undergo chlorination via this mechanism. (2 marks)  
 (v) State the condition/s required for compound **E** to react with chlorine. (1 mark)  
 (vi) Give an equation for the reaction of compound **E** with chlorine. (3 marks)  
 (vii) Give the mechanism for the reaction of compound **E** with chlorine. (8 marks)  
 (viii) Explain why compound **E** requires these conditions to react with chlorine. (4 marks)

*Total: 40 marks*



















