



L-Università
ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE
EXAMINATIONS BOARD

**INTERMEDIATE MATRICULATION LEVEL
2021 SECOND SESSION**

SUBJECT: **Chemistry**
DATE: 11th October 2021
TIME: 4:00 p.m. to 7:05 p.m.

Useful information

Ideal gas constant = $8.314 \text{ JK}^{-1}\text{mol}^{-1}$

Relative atomic masses: H = 1, C = 12, O = 16, Cl = 35.5

A Periodic Table is included.

SECTION A

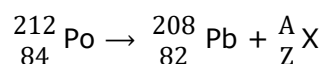
Answer ALL questions in this section.

1. (a) Give the symbol, including the mass number and the atomic number, of:

(i) an alpha particle: _____ (1)

(ii) a beta particle: _____ (1)

(b) The first naturally occurring unstable element that was isolated, polonium, was discovered by the Polish scientist Marie Curie and her husband Pierre in 1898. It decays as follows:



Identify X: _____ (1)

(Total: 3 marks)

2. Phosphorus and chlorine produce two compounds, PCl_3 and PCl_5 . One follows the octet rule while the other has 'octet expansion'.

(a) Draw dot-and-cross diagrams (showing outermost shell only) for the **TWO** chlorides.

(2)

This question continues on next page.

(b) Explain briefly what is meant by 'octet expansion.'

(1)

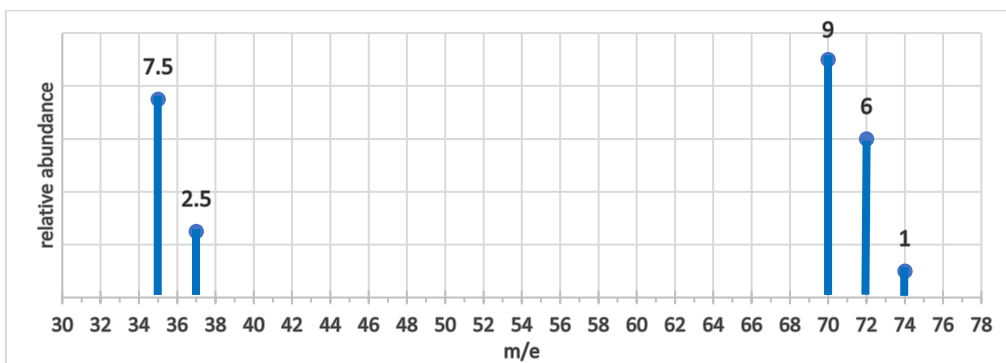
(Total: 3 marks)

3. Mark the following statements as True or False:

	True	False
(a) In group I of the periodic table, sodium is below lithium. The first ionisation energy of sodium is higher than that of lithium.		
(b) The first four elements in group VII of the periodic table are F, Cl, Br and I. The electronegativity increases down the group.		
(c) Metals are on the left-hand side of the periodic table. When they react, metals tend to lose electrons.		
(d) Fluorine, oxygen and nitrogen are the elements with the highest electronegativities, in that order.		

(Total: 4 marks)

4. The mass spectrum of a sample of chlorine gas is shown below.



Explain the following statements:

(a) There are two lines at m/e values of 35 and 37, at a ratio of 7.5:2.5 with respect to each other.

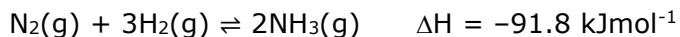
(2)

(b) There are three lines at m/e values of 70, 72 and 74.

(2)

(Total: 4 marks)

5. The reaction between nitrogen gas and hydrogen gas to give ammonia gas is an equilibrium reaction. The forward reaction is an exothermic reaction.



Explain what happens to the position of equilibrium and the value of the equilibrium constant K_c when:

(a) The concentration of nitrogen gas is increased.

(1)

(b) The pressure of the gaseous mixture is increased.

(1)

(c) The temperature is increased.

(2)

(Total: 4 marks)

6. There are acids, bases and alkalis.

(a) Distinguish between acids and bases in aqueous solution.

(2)

(b) Distinguish between bases and alkalis.

(1)

(c) Some substances are amphoteric. Explain.

(1)

(Total: 4 marks)

Please turn the page.

7. Consider the elements lithium to fluorine.

(a) What period number of the periodic table are they in? _____ (1)

(b) Consider the oxides of these elements in this period. Outline the trend in the melting point of these oxides by giving their physical states at room temperature.

_____ (1)

(c) Give the formulae of the chlorides of the elements in this period.

_____ (2)

(Total: 4 marks)

8. Fill in the blanks in the passage below with the following terms. You can use each term once, more than once or not at all.

substitution, cracking, dehydration, carbohydrates, symmetrical, bromine, hydrocarbons, unsymmetrical, nitrogen, addition, unsaturated, saturated.

Alkanes, alkenes and alkynes are _____. Alkanes are _____ compounds and typically undergo _____ reactions while alkenes and alkynes usually undergo _____ reactions. Alkanes and alkenes are obtained from petroleum by _____.

Alkanes react with _____ by a free radical mechanism. When a hydrogen halide (HX) reacts with an _____ alkene, Markownikov's rule predicts where the H and the X form a bond. Alkenes can be prepared by the _____ of alcohols.

(Total: 4 marks)

SECTION B

Answer ALL questions in this section.

9. (a) State Avogadro's Law.

(1)

(b) Consider the reaction: $2\text{CO}(\text{g}) + \text{O}_2(\text{g}) \longrightarrow 2\text{CO}_2(\text{g})$

If a gaseous mixture composed of 30 cm^3 of carbon monoxide and 20 cm^3 of oxygen reacts, how much carbon dioxide is produced? Show the working and indicate any assumptions used.

(2)

(c) Considering complete reaction between carbon monoxide and oxygen:

(i) Find the total volume of gas after reaction.

(1)

(ii) If the volume of carbon dioxide produced was at room temperature and pressure (RTP) and considering that the molar volume of a gas at RTP is 24 dm^3 , calculate the number of moles of carbon dioxide produced.

(2)

(Total: 6 marks)

Please turn the page.

10. (a) Benzene is an aromatic compound having a stable, delocalised structure. Explain each of the following terms:

(i) aromatic: _____

_____ (1)

(ii) delocalised: _____

_____ (1)

(b) Benzene undergoes several reactions. Assuming that any required catalyst is available, and at the right conditions, indicate the main product (by giving the name or the formula) in each of the following reactions of benzene:

(i) benzene + chlorine; _____

_____ (1)

(ii) benzene + sulfuric(VI) acid; _____

_____ (1)

(iii) benzene + nitrating mixture; _____

_____ (1)

(iv) benzene + hydrogen. _____

_____ (1)

(Total: 6 marks)

11. (a) The reaction between ethene and HBr takes place through a multistep reaction mechanism.

(i) Write the equation for this reaction.

_____ (1)

(ii) Write the mechanism for this reaction.

_____ (3)

(b) Which step of the mechanism is the rate determining step? Show your reasoning.

(2)

(Total: 6 marks)

12. A small volume of a volatile alcohol, of mass 0.152 g, is placed in a closed syringe. When the syringe is heated to 97 °C, the liquid evaporated occupying a volume of 100 cm³ at a pressure of 101,300 Pa.

(a) Find the relative atomic mass of the alcohol.

(3)

(b) Give the structural formula of the alcohol. Show your reasoning.

(2)

(c) This alcohol reacts with ethanoic acid in the presence of concentrated sulfuric acid to produce an ester. Write the structural formula of the ester.

(1)

(Total: 6 marks)

Please turn the page.

13. The electron pair repulsion theory can be used to predict the shapes of molecules.
- (a) By using the theory, draw the shapes of the following molecules: CH_4 , NH_3 , H_2O and HCl . Include lone pairs whenever present.

(4)

- (b) Indicate the main intermolecular forces present in each case.

Molecule	Intermolecular forces
Methane	
Ammonia	
Water	
Hydrogen chloride	

(2)

(Total: 6 marks)

SECTION C

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

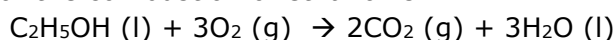
14. This question is about thermochemistry.

(a) Enthalpy changes are due to the breaking and the formation of bonds. These changes determine whether a reaction is exothermic or endothermic.

(i) Explain the meaning of the term exothermic and denote whether the enthalpy change is negative or positive. (1)

(ii) The combustion of ethanol is an exothermic process. Explain this statement in terms of the energy involved in bond breaking and bond formation. (3)

(iii) The equation for the combustion of ethanol is:



Rewrite the equation to show **all** the bonds in the reactants and products. (3)

(iv) Use the following bond energy terms in kJ mol^{-1} to calculate the enthalpy change for the combustion of ethanol with oxygen.

C-C = +347; C-H = +413; C-O = +358; O=O = +498; C=O = 745; O-H = +467 (4)

(v) The standard enthalpy change of combustion of ethanol determined from a calorimetric experiment is $-1367.3 \text{ kJ mol}^{-1}$. Suggest why this value differs from the value obtained in part (a)(iv), where bond energies were used. (2)

(b) The standard enthalpy change of combustion is used to calculate the standard enthalpy change of formation of a compound.

(i) Define the term standard enthalpy change of formation. (1)

(ii) Write a balanced chemical equation, including state symbols that describe the standard enthalpy change of formation of ethanol. (2)

(iii) Draw a cycle (Hess's cycle) to show the relation between the enthalpy change of combustion and the enthalpy change of formation of ethanol. (3)

(iv) Explain why the enthalpy change of formation of ethanol **cannot** be found directly by reacting carbon, hydrogen and oxygen. (1)

(Total: 20 marks)

15. This question is about acids and bases.

(a) Hydrochloric acid is made when hydrogen chloride (HCl) gas dissolves and reacts with water. In aqueous solution, hydrogen chloride behaves as a Brønsted Lowry acid.

(i) Define a Brønsted Lowry acid (1)

(ii) Write an equation to show the reaction of the gas HCl with water. (2)

(iii) Identify the acid-base conjugate pairs in your answer (in part (a)(ii)). (2)

(b) The pH is a measure of the acidity and alkalinity of a solution.

(i) Define pH. (1)

(ii) Two solutions of hydrochloric acid, solution P and solution Q, have a different pH. The pH of solution P is 1.3, whereas the pH of solution Q is 3.2. Which aqueous solution has more hydrogen ions than the other? (1)

(c) A volume of 50 cm^3 of an acidic solution R contains 0.15 g hydrogen chloride.

(i) Find the number of moles of hydrogen chloride. (1)

(ii) Find the pH of solution R. (3)

This question continues on next page.

- (d) A sample of an aqueous solution of sulfuric(VI) acid, S, has a concentration of $0.0125 \text{ mol dm}^{-3}$. The sulfuric(VI) acid was used in a titration to determine the concentration of a solution of sodium hydroxide. An acid-base indicator was used. 27.50 cm^3 of aqueous sodium hydroxide were required to react with 25 cm^3 of the sulfuric(VI) acid.
- (i) Calculate the pH of the solution S. (2)
 - (ii) Write a balanced chemical equation, including states symbols, for the reaction of sulfuric(VI) acid and aqueous sodium hydroxide. (2)
 - (iii) Why was an acid-base indicator used in the titration? (1)
 - (iv) Name an indicator which can be used in this reaction. (1)
 - (v) Find the number of moles of sulfuric(VI) acid in the reacting mixture. (1)
 - (vi) Calculate the molarity of the sodium hydroxide solution. (2)

(Total: 20 marks)

16. This question is about the chemistry of halogens.

- (a) One of the following mixtures will result in a chemical reaction.
Mixture X: bromine solution and sodium iodide ions
Mixture Y: bromine solution and sodium chloride ions
- (i) Identify the mixture which will result in a chemical reaction and write a balanced chemical equation for the reaction that takes place. (3)
 - (ii) Explain why a reaction occurs in the mixture which was chosen in part (a)(i). (2)
- (b) Concentrated sulfuric(VI) acid can be used to produce hydrogen halides from their salts. This is a good method to prepare hydrogen chloride, but not a good method to prepare hydrogen bromide or hydrogen iodide.
- (i) Write a balanced chemical equation which represents the preparation of hydrogen chloride using sulfuric(VI) acid. (2)
 - (ii) Explain why sulfuric(VI) acid is **not** used in the preparation of hydrogen bromide or hydrogen iodide. (3)
 - (iii) Name the compound which is used to prepare hydrogen bromide from its salt. (1)
- (c) The strong acids, hydroiodic, hydrochloric and hydrobromic acids – HI(aq), HCl(aq), HBr(aq) – are formed when water is added to hydrogen iodide, hydrogen chloride and hydrogen bromide respectively. Arrange these acids in order of their acid strengths, starting with the strongest acid and state the reason for this trend. (4)
- (d) The following reaction is used in industry to produce bleach.
- $$\text{Cl}_2 + 2\text{NaOH} \rightarrow \text{NaCl} + \text{NaClO} + \text{H}_2\text{O}$$
- (i) Give the oxidation numbers of Cl in NaCl and NaClO. (1)
 - (ii) Discuss why the above bleach reaction is a special type of redox reaction. In your answer, name the type of reaction and give your reasons. (2)
 - (iii) In the above bleach reaction, identify the ion which is responsible for the bleaching action and explain how this ion bleaches dyes and stains. (2)

(Total: 20 marks)

