



**Coimisiún na Scrúduithe Stáit  
State Examinations Commission**

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**LEAVING CERTIFICATE EXAMINATION, 2003**

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**CHEMISTRY - HIGHER LEVEL**

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TUESDAY, 17 JUNE - AFTERNOON 2.00 to 5.00

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**400 MARKS**

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Answer **eight** questions in all

These **must** include at least **two** questions from **Section A**

All questions carry equal marks (50)

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**Information**

Relative atomic masses: H = 1, C = 12, N = 14, O = 16, Na = 23, Fe = 56.

Molar volume at s.t.p. = 22.4 l

Avogadro constant =  $6 \times 10^{23} \text{ mol}^{-1}$

Universal gas constant,  $R = 8.3 \text{ J K}^{-1} \text{ mol}^{-1}$

## Section A

Answer at least two questions from this section [see page 1 for full instructions]

1. Iron tablets may be used in the treatment of anaemia.

To analyse the iron(II) content of commercially available iron tablets a student used four tablets, each of mass 0.360 g, to make up 250 cm<sup>3</sup> of solution in a volumetric flask using dilute sulfuric acid and deionised water.

About 15 cm<sup>3</sup> of dilute sulfuric acid was added to 25 cm<sup>3</sup> portions of this iron(II) solution and the mixture then titrated with a 0.010 M solution of potassium manganate(VII), **KMnO<sub>4</sub>**.

- (a) Why was it important to use dilute sulfuric acid as well as deionised water in making up the solution from the tablets? (5)
- (b) Describe in detail the procedure for making up the 250 cm<sup>3</sup> solution from the tablets. (18)
- (c) Why was more dilute sulfuric acid added before the titrations were commenced? (6)
- (d) How was the end-point detected? (3)

The titration reaction is described by the equation



- (e) In the titrations the 25 cm<sup>3</sup> portions of the iron(II) solution made from the tablets required 13.9 cm<sup>3</sup> of the 0.010 M **KMnO<sub>4</sub>** solution. Calculate
- (i) the concentration of the iron(II) solution in moles per litre
- (ii) the mass of iron(II) in one tablet
- (iii) the percentage by mass of iron(II) in each tablet. (18)

2. The diagram shows an apparatus that can be used for the preparation of ethyne gas,  $C_2H_2$ .

A liquid **X** is dropped onto the solid **Y** and the gas collected in test tubes as shown.

(a) Identify the liquid **X** and the solid **Y**. (8)

(b) Describe the appearance of the solid **Y**. (3)

(c) Write a balanced equation for the reaction between **X** and **Y** producing ethyne. (6)

(d) What is observed when a sample of ethyne gas is burned in air?

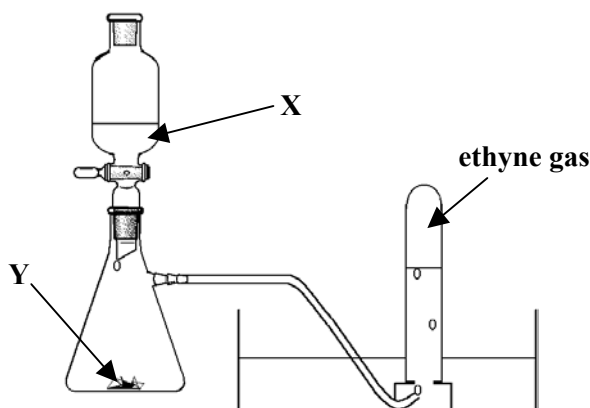
Write a balanced equation for the combustion of ethyne in oxygen. (9)

(e) Ethyne,  $C_2H_2$ , is described as an *unsaturated* hydrocarbon.

Describe a test you could carry out to show that ethyne is *unsaturated*.

Write an equation for the reaction taking place. Name the organic product. (18)

(f) The common name for ethyne gas,  $C_2H_2$ , is acetylene. Give **one** major use of the gas. (6)



3. In an experiment to determine the relative molecular mass of a volatile liquid a sample of the liquid is vaporised at a given temperature and pressure and its volume measured. The mass of the sample is also measured. The number of moles of liquid is then calculated using the formula  $PV = nRT$  and from this the relative molecular mass of the liquid is calculated.

(a) What is meant by a *volatile liquid*? (5)

(b) Describe with the aid of a labelled diagram how you would carry out this experiment to determine the relative molecular mass of a volatile liquid. From your description it should be clear how the *mass*, *volume*, and *temperature*, of the sample are measured. (21)

(c) How may the *pressure* be measured? (6)

In an experiment to measure the relative molecular mass of a volatile liquid 0.275 g of the liquid was vaporised at  $97^\circ C$ . The volume occupied was found to be  $95\text{ cm}^3$ . The pressure was  $1 \times 10^5\text{ Pa}$ .

(d) Calculate the number of moles of the volatile liquid vaporised. (12)

(e) Calculate the relative molecular mass of the volatile liquid. (6)

## Section B

[See page 1 for instructions regarding the number of questions to be answered]

4. Answer **eight** of the following items (a), (b), (c), etc. (50)

(a) How many (i) electrons and (ii) neutrons has  ${}_{17}^{37}\text{Cl}^-$  ?

(b) How many electrons are there in 2.3 g of sodium metal, Na?

(c) The famous Irish scientist shown on the right, was born in 1627. He was a son of the Earl of Cork. Give a statement of the gas law that bears his name.

(d) On what principle is the analytical technique *mass spectrometry* based?

(e) What happens during *secondary* sewage treatment?

(f) List the following three types of radiation in order of increasing penetrating power

**alpha- ( $\alpha$ -)**

**beta- ( $\beta$ -)**

**gamma- ( $\gamma$ -)**

(g) What is the percentage by mass of nitrogen in ammonium nitrate,  $\text{NH}_4\text{NO}_3$ ?

(h) Draw the structure and give the name of an *ester* of the molecular formula  $\text{C}_3\text{H}_6\text{O}_2$ .

(i) State **two** ways in which Mendeleev's periodic table of the elements differs from that of Moseley.

(j) State **two** ways, other than the addition of lead compounds, that the octane rating of a fuel can be increased.

(k) Answer part **A** or **B**

**A** Describe with the aid of an equation how *nitrogen fixation* occur in nature.

**or**

**B** State **two** properties of transition metals.



5. (a) Define (i) *energy level* (ii) *atomic orbital*. (8)

(iii) Write the electronic configuration (*s*, *p*, etc.) of nitrogen.

(iv) Describe how the electrons are arranged in the orbitals of the highest occupied sub-level of a nitrogen atom in its ground state. (6)

(b) Define *electronegativity*. (6)

(i) Describe using dot and cross diagrams the bonding in the water molecule. (9)

(ii) What is the shape of the water molecule?

Which of the following angles,  $104^\circ$ ,  $107^\circ$ ,  $109^\circ$ ,  $120^\circ$  or  $180^\circ$  would you expect to be closest to the bond angle in the water molecule?

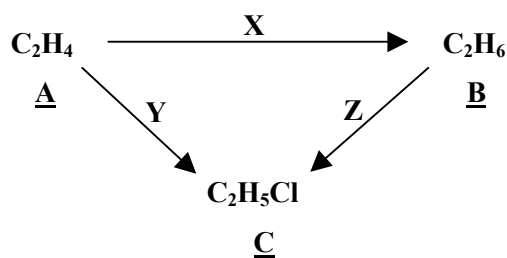
Explain your answer. (12)

(c) The diagram on the right shows a thin stream of water flowing from a burette.

What would you observe if a charged rod was brought close to the thin stream of water? Explain your answer. (9)



6. Study the reaction scheme and answer the questions which follow.



- (a) Which of the compounds A, B and C has no tetrahedrally bonded carbon atoms?  
Draw the structure of a molecule of this compound. (8)
- (b) Classify the conversions X, Y and Z as *addition*, *substitution* or *elimination* reactions. (9)
- (c) What reagent is used to convert A to C? (3)
- (d) What reagent and what conditions are required for the conversion of B to C? (6)
- (e) Describe the mechanism of the reaction for the conversion of A to C. (18)  
State **one** piece of experimental evidence which supports the mechanism you have proposed. (6)
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7. (a) Define *rate of a chemical reaction*. (5)

Calcium carbonate (marble chips) reacts with hydrochloric acid according to the following equation.

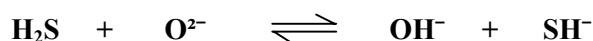


Using simple experiments involving marble chips,  $\text{CaCO}_3$ , and hydrochloric acid,  $\text{HCl}$ , describe how you could demonstrate the effects of

- (i) *particle size*, (ii) *concentration* on the rate of a chemical reaction. (18)
- (b) What is a *catalyst*? (6)  
Catalytic converters are used in cars.
- (i) Identify **one** reaction which is catalysed in the catalytic converter in a car.  
State **one** of the environmental benefits of this process. (12)
- (ii) Name **one** element used as a catalyst in a catalytic converter.  
What type of catalysis is involved in a catalytic converter? (9)
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8. (a) Define (i) *an acid*, (ii) *a base* according to the Brønsted-Lowry theory. (8)

Identify the *acid*, and *conjugate acid* in the following system. (6)



- (b) Define pH. (6)  
A bottle of vinegar is labelled 6% (w/v) acetic acid (ethanoic acid). The dissociation constant,  $K_a$ , for ethanoic acid is  $1.8 \times 10^{-5}$ . Calculate the approximate pH of the vinegar solution. (12)
- (c) The *free chlorine* present in swimming-pool water can be measured using a colorimeter or comparator.
- (i) What is the principle on which the technique that uses each of these methods is based? (12)
- (ii) What is meant by *free chlorine*? (6)
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9. (a) Draw the structure and state the IUPAC name for the aldehyde of the molecular formula  $C_3H_6O$ . (8)

Draw the structure and give the name of another carbonyl compound that has the same molecular formula,  $C_3H_6O$ . Give **one** use of this compound. (12)

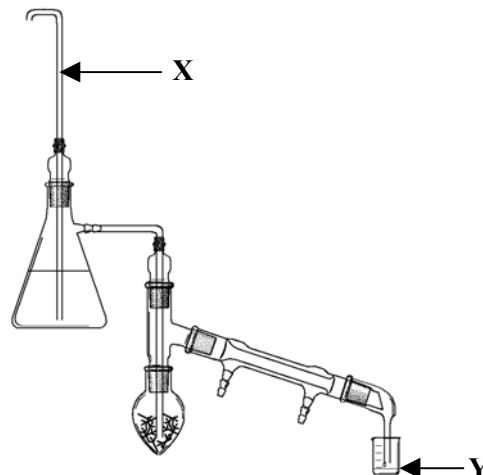
Which of these two carbonyl compounds is easily oxidised to a carboxylic acid? Name that acid. (6)

- (b) The diagram shows the arrangement of glassware for the extraction of clove oil from cloves by steam distillation.

(i) What is the purpose of the tube marked X? (6)

(ii) What is collected at Y? Describe its appearance. (12)

(iii) State **one** use of clove oil. (6)



10. Answer any **two** of the parts (a), (b) or (c) (2 × 25)

(a) Define *heat of combustion*. (7)

Propane may be used in gas cylinders for cooking appliances. Propane burns according to the equation



(i) The heats of formation of propane, carbon dioxide and water are  $-104$ ,  $-394$  and  $-286 \text{ kJ mol}^{-1}$  respectively. Calculate the heat of combustion of propane. (12)

(ii) If 500 kJ of energy are needed to boil a kettle of water what mass of propane gas must be burned to generate this amount of heat? Express your answer to the nearest gram. (6)

(b) Use the data below to sketch (on graph paper) the pH curve for a titration between  $20 \text{ cm}^3$  of ethanoic acid and a sodium hydroxide solution added from a burette. (18)

<b>Volume of NaOH added (<math>\text{cm}^3</math>)</b>	0	5	10	15	17	19	21	23	25	30	35	40
<b>pH</b>	3.1	4.2	4.8	5.2	5.6	6.0	11.2	11.6	12.1	12.4	12.5	12.6

What indicator would you use for this titration? Use the graph to explain your choice. (7)

(c) A student was given samples of the following salts:

**sodium sulfate ( $Na_2SO_4$ )**

**sodium sulfite ( $Na_2SO_3$ )**

**potassium sulfate ( $K_2SO_4$ )**

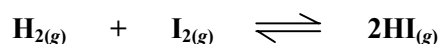
(i) What test could be carried out to distinguish between the sodium salts and the potassium salt? (4)  
What observation would you make in this test? (6)

(ii) Describe the test which could be carried out to distinguish between the sulfate salts and the sulfite salt. (15)

11. Answer any **two** of the parts (a), (b) or (c) (2 × 25)

(a) State *Le Chatelier's principle*. (7)

A gaseous mixture of hydrogen, iodine and hydrogen iodide form an equilibrium according to the following equation.



(i) Write an expression for the equilibrium constant,  $K_c$ , for this system. (6)

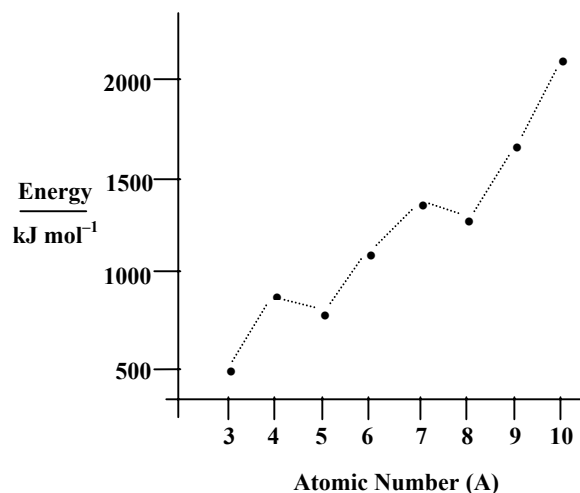
(ii) The value of the equilibrium constant,  $K_c$ , for this reaction is 50 at 721 K. If 2 moles of hydrogen iodide gas were introduced into a sealed vessel at this temperature calculate the amount of hydrogen iodide gas present when equilibrium is reached. (12)

(b) The diagram shows a sketch of the trend in the first ionisation energies for the elements 3 to 10 in the periodic table.

(i) Account for the general increase in ionisation energies across these elements. (7)

(ii) Explain why the ionisation energies of element number 4 and 7 are exceptionally high relative to the general trend. (12)

(iii) How does the definition of second ionisation energy differ from that of first ionisation energy? (6)



(c) Answer part **A** or part **B**

**A**

What is the chemical formula for ozone? State **one** beneficial effect of the ozone layer. (7)

CFCs are believed to be the main cause of damage to the ozone layer.

(i) What are CFCs? What use is made of CFCs? (6)

(ii) Explain how CFCs may give rise to ozone depletion. (12)

*or*

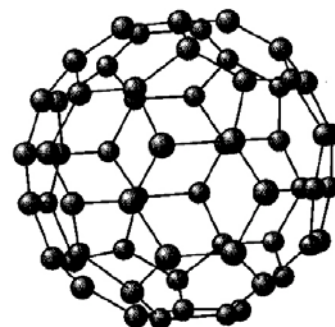
**B**

The structure of a buckminsterfullerene with 60 atoms is drawn on the right.

(i) Atoms of what element make buckminsterfullerenes? (4)

(ii) Name **two** other covalent macromolecular crystals formed by this element. What are the binding forces in each of these crystals? (15)

Give **one** use for **each** of these two substances. (6)



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