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Pre-Leaving Certificate Examination, 2012
Triailscrúdú na hArdteistiméireachta, 2012

CHEMISTRY — HIGHER LEVEL

TIME: 3 HOURS

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400 MARKS

Answer **eight** questions in all
These **must** include at least **two** questions from **Section A**
All questions carry equal marks (50)

The information below should be used in your calculations.

Relative atomic masses: H = 1, C = 12, O = 16, Na = 23, Cl = 35.5, Ca = 40, Cr = 52

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

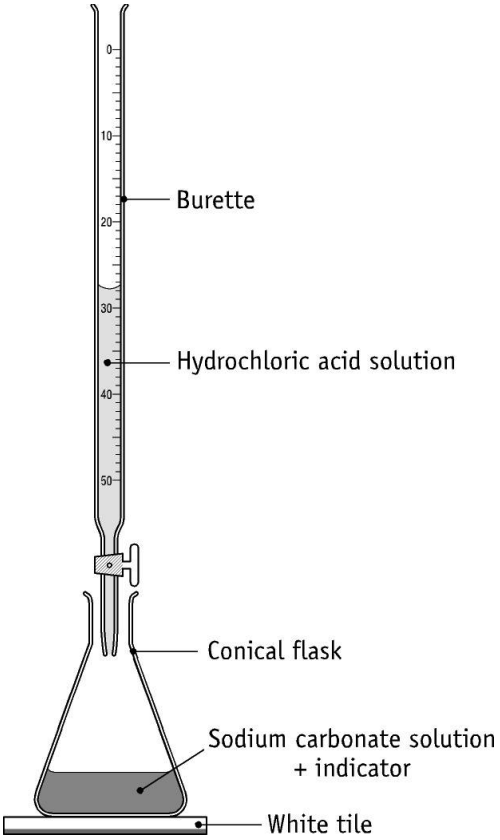
Avogadro constant = 6×10^{23} mol^{-1}

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

Section A

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

1. In an experiment 4.69 grams of hydrated sodium carbonate **($Na_2CO_3.xH_2O$)** were weighed out and dissolved in deionised water. The solution was then made up to 250 cm^3 in a volumetric flask. 20.0 cm^3 of this solution was transferred to a conical flask and titrated against a standard 0.13 M hydrochloric acid solution using a suitable indicator.



(a) Describe the procedure for dissolving the hydrated salt and making up the solution to 250 cm^3 in the volumetric flask. (15)

(b) Name a suitable indicator for the titration and state the colour change observed in the conical flask at the end point. (6)
Explain why not more than 1 – 2 drops of indicator should be used. (5)

(c) After carrying out a number of accurate titrations using the 20 cm^3 of sodium carbonate solution the mean titration figure was found to be 20.17 cm^3 of the 0.13 M hydrochloric acid solution.

The titration reaction is:

$$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2$$

Calculate the concentration of the sodium carbonate solution in
(i) moles per litre,
(ii) grams per litre. (9)

(d) Calculate the weight of water in the original sample and hence the percentage of water crystallisation in the hydrated sodium carbonate. Calculate the degree of hydration i.e. the value of **x** of the original crystals. (15)

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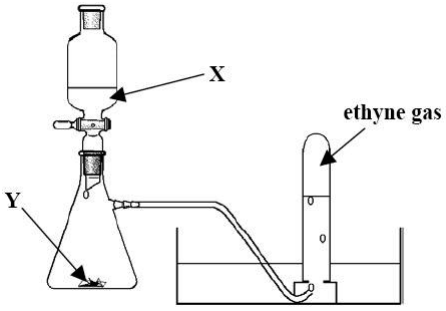
2. The diagram shows an apparatus that can be used for the preparation of ethyne gas, **(C_2H_2)**.
A liquid **X** is dropped onto the solid **Y** and the gas is collected in test tubes as shown.



(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) Name **two** impurities found in the ethyne gas produced and explain how these impurities may be removed. (9)

(e) Ethyne, **(C_2H_2)**, is described as an unsaturated hydrocarbon.
What is meant by the term *unsaturated*? Name the reagent used to test for unsaturation and state the type of reaction involved. (12)

(f) What is the common name for ethyne and state one major use of the gas? (6)

(g) In which of the two solvents, water or methylbenzene, is ethyne soluble? Explain why. (6)

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3. In an experiment to determine the relative molecular mass of a <u>volatile liquid</u>, 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 <u>relative molecular mass</u> of the liquid is calculated.

(a) Explain the underlined terms? (6)

(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? (5)

(d) In an experiment to measure the relative molecular mass of a volatile liquid, 0.25g of the liquid was vaporised at 97 °C. The volume occupied was found to be 132 cm^3. The pressure was 1×10^5 Pa.
(i) Calculate the number of moles of the volatile liquid vaporised. (12)
(ii) 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) What is the oxidation number of sulfur in $\mathbf{Na_2S_2O_3}$?

(b) How could you confirm the presence of sulfate $\mathbf{(SO_4^{2-})}$ ions in an aqueous solution?

(c) What is an *ideal gas*?

(d) How many atoms are present in 560 cm^3 of methane at s.t.p?

(e) Distinguish between sigma (σ) and pi (π) covalent bonding.

(f) What spectroscopic technique is used to detect heavy metals, e.g. lead, in environmental analysis?

(g) Write the electronic configuration of a neutral copper atom.

(h) Define *isotope*.

(i) Draw the structure and give the IUPAC name for $\mathbf{CH_3COCH_3}$.

(j) State *Charles's law*.

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

A Write an equation for the photodissociation of ozone.

or

B What are the structural differences between low-density and high-density poly(ethene)?

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5. *(a)* Define *electronegativity*. (5)

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

(ii) What is the shape of the ammonia molecule? Which of the following angles, 104°, 107°, 109°, 120° or 180° would you expect to be closest to the bond angle in the ammonia molecule? Explain your answer. (9)

(b) Define (*i*) *energy level,* (*ii*) *atomic orbital*. (6)
Write the electron configuration (*s, p, etc.*) of an iron atom in its ground state. (6)
Use the electronic configurations of $\mathbf{Fe^{2+}}$ and $\mathbf{Fe^{3+}}$ ions to predict which is the more stable of the iron ions. (6)

(c) Ethene, $\mathbf{(C_2H_4)}$ (Mr = 28) and methanal **(HCHO)** (Mr = 30), would be expected to have similar boiling points. However ethene boils at 169K and methanal boils at 252K. Explain this in terms of intermolecular forces. (9)

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6. *(a)* The octane number of a fuel is described as a *measure of the tendency of the fuel to cause knocking, or as a measure of the tendency of the fuel to resist auto-ignition.* This number is found by comparing the combustion of the fuel with the combustion of a mixture of two reference hydrocarbons using the same standard engine.

(i) Name and draw the structure of **both** of the reference hydrocarbons present in the mixture used when measuring octane number by this comparison method. (8)

(ii) State **two** structural features of a hydrocarbon molecule which contribute to it having a high octane number. (6)

(iii) Lead compounds were used in the past to increase the octane number of fuels. Why are lead compounds unsuitable as additives for petrol used in modern cars? (3)

(iv) Identify **one** additive or **type** of additive, other than a compound of lead, used to increase the octane number of fuels. (6)

(b) Name **three** processes that are carried out in an oil refinery to modify the hydrocarbon structure and improve their octane number. (9)

(c) Define the *heat of combustion*. (6)

(d) The combustion of heptane is described by the following equation:

$$\mathbf{C_7H_{16\,(l)} + 11O_{2\,(g)} \longrightarrow 7CO_{2\,(g)} + 8H_2O_{(l)}}$$

Given that the heats of formation of carbon dioxide gas, liquid water and liquid heptane are –394, –286 and –224.2 kJ mol^{-1} respectively, calculate the heat of combustion of liquid heptane. (12)

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7. *(a)* Define the *rate of a chemical reaction*.
Name **five** factors that can affect the rate of a chemical reaction (8)

(b) The rate of reaction between an excess of marble chips ($\mathbf{CaCO_3}$) (diameter 10 – 15 mm) and 100 cm^3 of 2.0 M hydrochloric acid was monitored by measuring the mass of carbon dioxide produced. The table shows the total mass of carbon dioxide gas produced at stated intervals over 9 minutes.

Time/minutes	0.0	1.0	2.0	3.0	4.0	5.5	7.0	8.0	9.0
Mass of CO_2/g	0.00	1.32	2.40	3.20	3.80	4.20	4.36	4.40	4.40

Plot a graph of the mass of carbon dioxide produced versus time. (12)
Use the graph to determine:

(i) the instantaneous rate of reaction in grams per minute at 3.00 minutes,

(ii) the instantaneous rate of reaction at this time in moles per minute. (9)

(c) Describe and explain the effect on the rate of reaction of repeating the experiment using 100 cm^3 of 1.0 M hydrochloric acid (**HCl**) and the same mass of the same size marble chips. (6)

(d) Particle size has a critical effect on the rate of a chemical reaction.

(i) Mark clearly on your graph the approximate curve you would expect to plot if the experiment were repeated using 100 cm^3 of 2.0 M **HCl** and using the same mass of marble chips but this time with a diameter range of 1 – 5 mm. (6)

(ii) Dust explosions present a risk in industry. Give **three** conditions necessary for a dust explosion to occur. (9)

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8. *(a)* State *Le Chatelier's Principal*. (5)
The formation of ammonia from its elements is shown in the following reversible reaction. This is an important process in the fertilizer industry.

$$\mathbf{N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3\,(g)} \qquad \Delta H = -92.4\ kJ\ mol^{-1}}$$

(b) What is the name given to this industrial process? (3)

(c) Write the equilibrium constant expression ($\mathbf{K_c}$) for the reaction above. (6)

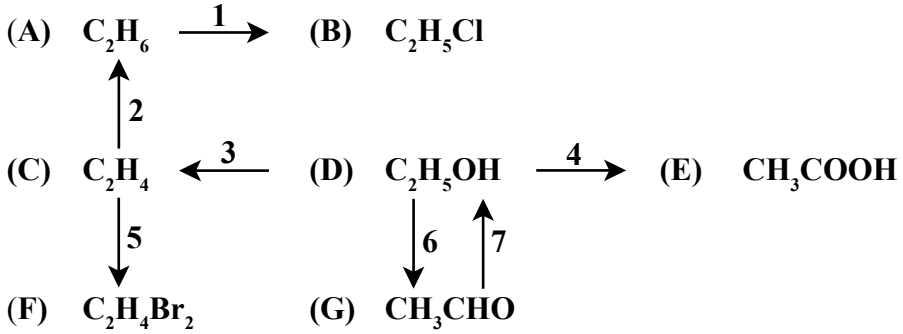
(d) In an experiment 4.5 moles of nitrogen and 13.5 moles of hydrogen were mixed in a 2 litre vessel at a certain temperature. It was found that there was 3.0 moles of ammonia in the equilibrium mixture.
(i) Calculate the concentration of each gas at equilibrium in moles/litre.
(ii) Calculate the value of the equilibrium constant ($\mathbf{K_c}$) at this temperature. (15)

(e) Name the catalyst used in this reaction? (3)

(f) State and explain the ideal conditions of temperature and pressure needed to maximize the yield of ammonia. (12)

(g) What conditions are actually used and explain the reason for each? (6)

9.



(a) Give the systematic (IUPAC) names of **A, B, C, D. E. F** and **G** (7)

(b) Name **three** compounds which contain at least one planar carbon. (9)

(c) Compound **A** may be converted to **B**. What reagent and what conditions are required. (6)

(d) Select from the scheme above:

(i) **one** elimination reaction, (3)

(ii) **two** oxidation reactions. (6)

For **each** of the reactions selected state the reagent(s) used. (9)

(e) Name the reagent and catalyst used in conversion **7** which converts **G** to **D**. (6)

(f) Which of the conversions above proceeds using an ionic addition mechanism? (4)

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10. Answer any **two** of the parts (a), (b) and (c).

(a) Ethanal is prepared in the laboratory according to the following equation:

$$3C_2H_5OH + Cr_2O_7^{2-} + 8H^+ \longrightarrow 3CH_3CHO + 2Cr^{3+} + 7H_2O$$

If 11.92 g of sodium dichromate ($Na_2Cr_2O_7.2H_2O$) and 2.3 g of ethanol (C_2H_5OH) are used in the reaction determine which of the two reagents are present in excess. (13)

After purification 1.32 g of ethanal was obtained, calculate the percentage yield.(12)

[Relative atomic masses: Na = 23, Cr =52, O =16, H = 1, C = 12]

(b) What is meant by the Biochemical Oxygen Demand (BOD) of a water sample? (6)

Explain the term *euthrophication*. (4)

50 cm^3 of water from a stream was diluted to 1 litre with distilled water and then divided into two portions. The dissolved oxygen concentration of one of the portions was measured immediately and was found to be 9.8 p.p.m. After storing the other portion for a period of time and under certain conditions for the determination of BOD the dissolved oxygen concentration was found to be 2.6 p.p.m.

(i) For how long and under what conditions was the second portion stored? (6)

(ii) Calculate the BOD of the **undiluted** stream water. (6)

(iii) Express p.p.m. as another unit of concentration. (3)

(c) Explain how an acid-base indicator, which is itself a weak acid and is represented by **HX**, functions. (10)

Calculate the pH of a 0.2 M nitrous acid (HNO_2) solution given that the dissociation constant K_a for nitrous acid is 5.0×10^{-4}. What is the pH of a nitric acid (HNO_3) solution of the same concentration? (15)

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11. Answer any **two** of the parts (a), (b) and (c).

(a) Describe a test which could be carried out to identify the presence of the phosphate ions in aqueous solution. (15)
What test could be carried out to distinguish between the two phosphate salts copper phosphate ($\mathbf{Cu_3(PO_4)_2}$) and sodium phosphate ($\mathbf{Na_3PO_4}$)? (4)
What observation would be made in this test? (6)

(b) How does the oxidation number of a reducing agent change during a redox reaction? (4)
Use oxidation numbers to identify the reducing agent in **each** of the following equations. (6)

$$\mathbf{Cl_2 + SO_3^{2-} + H_2O \longrightarrow Cl^- + SO_4^{2-} + H^+}$$

$$\mathbf{H^+ + MnO_4^- + C_2O_4^{2-} \longrightarrow CO_2 + Mn^{2+} + H_2O}$$

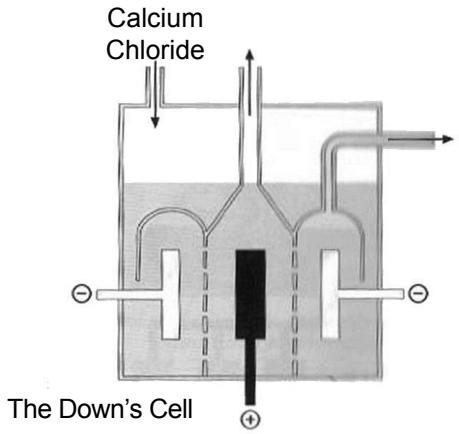
Hence or otherwise balance both equations. (15)

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

A
(i) Explain the term *greenhouse effect.* (7)
(ii) Name **three** significant greenhouse gases? (6)
(ii) Explain the source of **one** of these gases. (3)
(iv) Name **one** gas in the atmosphere which is not a greenhouse gas? (3)
(v) Explain the role of the ocean in controlling the greenhouse effect. (6)

or

B Sodium is extracted from its ores by electrolysis using the Down's cell (see diagram). Calcium chloride is added to the sodium ore before electrolysis.
(i) Why is this necessary? (6)
(ii) What materials are used for the anode **and** the cathode? (6)
(iii) Write the equation for the reaction which occurs at the cathode. (3)
(iv) What is the purpose of the steel gauze separating the two electrode compartments? (6)
(v) State **one** use of sodium. (4)



The Down's Cell