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KEARSNEY COLLEGE TRIAL EXAMINATION

12 SEPTEMBER 2017

PHYSICAL SCIENCES: PAPER 2

Time: 3 hours

200 marks

EXAMINATION NUMBER

1	7	1	0	6	8	0	2				
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EXAMINER: Mr Thompson

MODERATOR: Mr Moerdyk

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 15 pages, an Answer Sheet of 1 page (page 16 and 17) and a Data sheet of 3 pages.
2. Please make sure that your question paper is complete.
3. **Write your examination number on the Answer Sheet.**
4. Read the questions carefully.
5. ALL of the questions in this paper must be answered.
6. Question 1 consists of 10 multiple-choice questions. There is only one correct answer to each question. The questions are answered on the Answer Sheet provided on the inside cover of your Answer Book. The letter that corresponds with your choice of the correct answer must be marked with a cross as shown in the example below:

A	B	C	D
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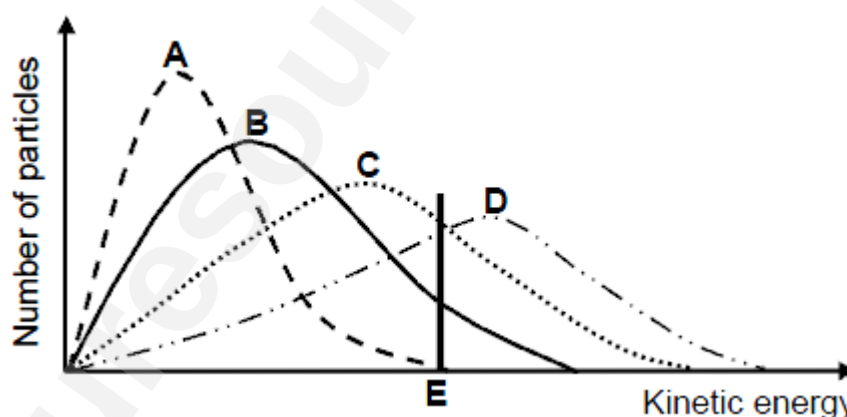
Here the answer C has been marked.

7. **START EACH QUESTION ON A NEW PAGE.**
8. Number your answers exactly as the questions are numbered.
9. Unless instructed otherwise it is NOT necessary to give state symbols (phase indicators) when asked to write a balanced chemical equation.
10. Use the data and formulae whenever necessary.
11. Show all of the necessary steps in calculations.
12. Where appropriate take your answers to 2 decimal places.
13. It is in your own interest to write legibly and to set your work out neatly.

QUESTION 1 MULTIPLE CHOICE

Answer these questions on the Multiple-choice Answer Sheet inside the front cover of your Answer Book. Make a cross (X) in the box corresponding to the letter which you consider to be the most correct.

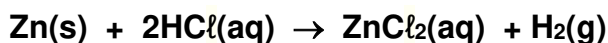
- 1.1 The chemical formula of chromium (III) hydrogen carbonate is:
- A CrH_2CO_3
 - B $\text{Cr}(\text{HCO}_3)_3$
 - C $\text{Cr}_2(\text{HCO}_3)_3$
 - D CrHCO_3
- 1.2 Diamond has a very high melting point as a result of the energy needed to break the many strong.
- A covalent bonds between atoms
 - B electrostatic forces between ions
 - C London forces between molecules
 - D dipole-dipole forces between atoms
- 1.3 The Maxwell-Boltzmann energy distribution curves below show the number of particles as a function of their kinetic energy for a reaction at four different temperatures. The minimum kinetic energy needed for effective collisions to take place is represented by E.



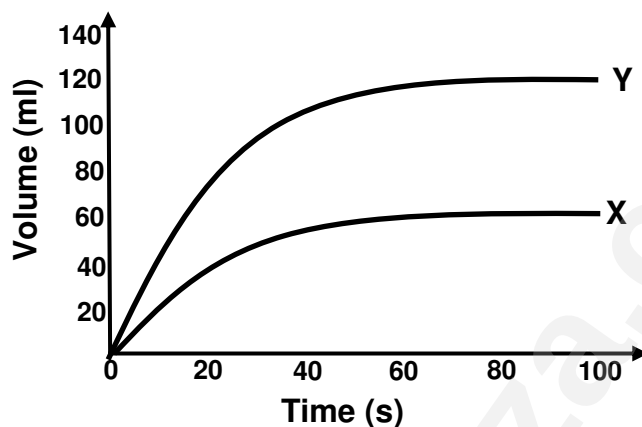
Which ONE of these curves represents the reaction with the highest rate?

- A A
- B B
- C C
- D D

- 1.4 Hydrochloric acid was reacted with **excess** zinc and the hydrogen gas produced was collected. The balanced chemical equation for the reaction is given below.



Graph **X** shows the volume of gas produced in an experiment using dilute hydrochloric acid with excess zinc. Graph **Y** represents a new experiment where the reaction conditions were changed but the zinc remained in excess.

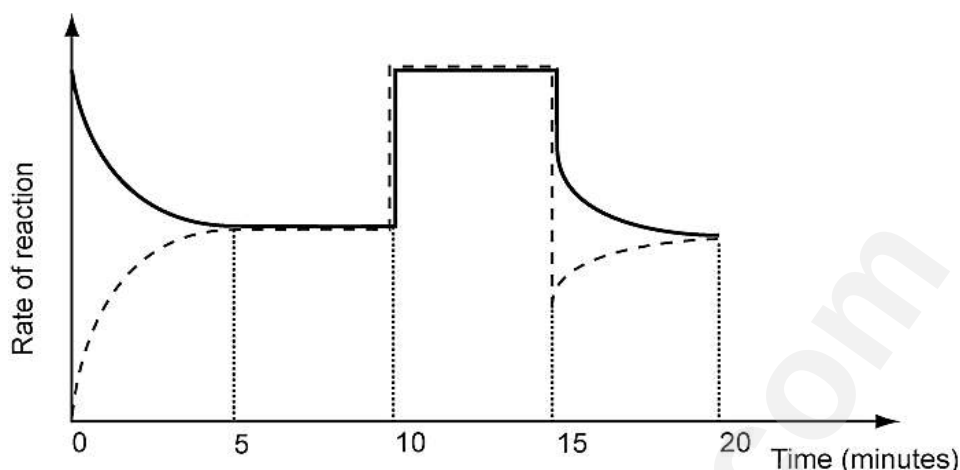
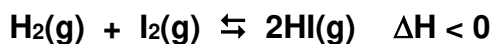


What reaction condition was changed in experiment Y compared with experiment X?

- A An increase in the mass of zinc.
 - B An increase in the concentration of HCl
 - C An increase in the volume of HCl
 - D Using powdered zinc in place of the granules.
- 1.5 The average mass of a crystal of NaCl is 3,2 mg. The number of ions in a crystal of NaCl is ...

- A $\frac{0,0032 \times 2}{58,5 \times 6,02 \times 10^{23}}$
- B $\frac{0,0032 \times 6,02 \times 10^{23}}{58,5}$
- C $\frac{0,0032 \times 6,02 \times 10^{23}}{58,5 \times 2}$
- D $\frac{0,0032 \times 6,02 \times 10^{23} \times 2}{58,5}$

1.6 The following reversible reaction reaches equilibrium in a closed container:



Equilibrium was first established after 5 minutes.

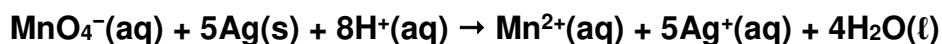
What change in the conditions was made at 15 minutes to change the rate of the reaction as indicated on the graph?

- A A catalyst was added.
- B The temperature was increased.
- C The temperature was decreased.
- D The external pressure on the reaction mixture was decreased.

1.7 1,0 mol.dm⁻³ solutions of H₂SO₄, HCl and CH₃COOH are prepared. When comparing the three solutions, which of the following statements is correct?

- A The CH₃COOH solution has the lowest pH.
- B The H₂SO₄ solution has the lowest [H₃O⁺]
- C The CH₃COOH has the lowest ionisation constant (K_a)
- D The HCl solution has the lowest electrical conductivity

1.8 Consider the following redox reaction:



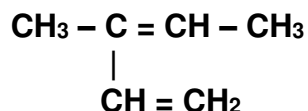
The oxidising agent is:

- | | |
|--------------------|---------------------------------|
| A Ag | B Ag ⁺ |
| C Mn ²⁺ | D MnO ₄ ⁻ |

1.9 Why is it necessary to dissolve aluminium oxide in molten cryolite during the extraction of aluminium?

- A The cryolite reduces the melting point of the aluminium oxide.
- B The cryolite acts as a catalyst for the production of aluminium
- C The cryolite reacts with aluminium oxide to form aluminium.
- D Aluminium oxide can only conduct electricity when mixed with cryolite.

1.10 Which is the correct IUPAC name for the following organic compound?



- A 3-methylpent-2,4-diene
- B 3-methylpent-1,3-diene
- C 2-ethylbut-2-ene
- D hex-1,3-diene

[20]

QUESTION 2

CHEMICAL BONDING

- 2.1 Ammonia (NH₃) and phosphine (PH₃) are both hydrides of elements in group 15. Their boiling points are given in the table below.

Name	Formula	Boiling point (°C)
Ammonia	NH ₃	-33,34
Phosphine	PH ₃	-87,7

- 2.1.1 Name the **specific** type of intramolecular bond present in:

- (a) ammonia. (2)
 (b) phosphine. (2)

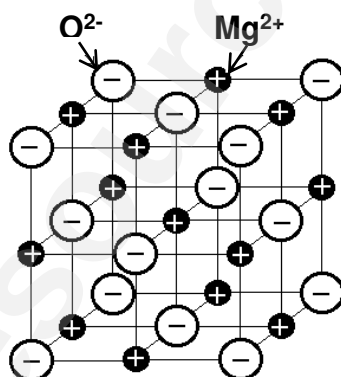
- 2.1.2 Define *intermolecular force*. (2)

- 2.1.3 Name the type of intermolecular force present in:

- (a) ammonia. (1)
 (b) phosphine. (1)

- 2.1.4 Explain why ammonia has a significantly higher boiling point than phosphine. (2)

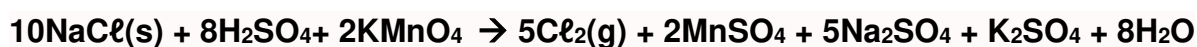
- 2.2 Consider the following diagram showing the bonding in magnesium oxide.



Magnesium oxide

- 2.2.1 Name the type of bond present between the particles in magnesium oxide. (1)
 2.2.2 State TWO different conditions under which magnesium oxide is able to conduct electricity and briefly explain why it can conduct under these conditions. (3)
 2.2.3 Why is it incorrect to refer to a “molecule” of MgO? (2)
 2.2.4 Explain why MgO has such a high melting point (2 852 °C). (3)

- 2.3 The purity of a sample of NaCl was tested by means of a redox reaction represented by the following balanced chemical equation:



When 20 g of impure NaCl was treated with excess H₂SO₄ and KMnO₄, 3,36 dm³ of chlorine gas (Cl₂) was formed at STP. Calculate the % purity of the NaCl sample. (7)

[26]

QUESTION 3**ENERGY CHANGE AND RATES OF REACTION**

The chemical compound methyl isocyanate (MIC) is used in the production of pesticides. The molecular formula of MIC is CH_3NCO . MIC reacts with water as shown in the balanced chemical equation:



3.1 On the axes provided on the **ANSWER SHEET** draw a potential energy profile graph to represent the above reaction.

Label the following:

- Energy of the reactants
- Energy of the products
- Activated complex
- Activation energy (E_A)
- Heat of reaction, ΔH

(6)

An iron catalyst is used in the above reaction.

3.2 Define *catalyst*.

(2)

3.3 Draw a dashed line (- - - -) on your graph to show the effect of a catalyst.

(1)

3.4 Explain, in terms of the collision theory, how a catalyst achieves its function.

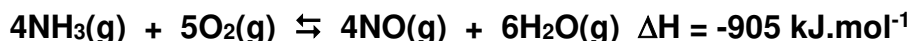
(3)

[12]

QUESTION 4

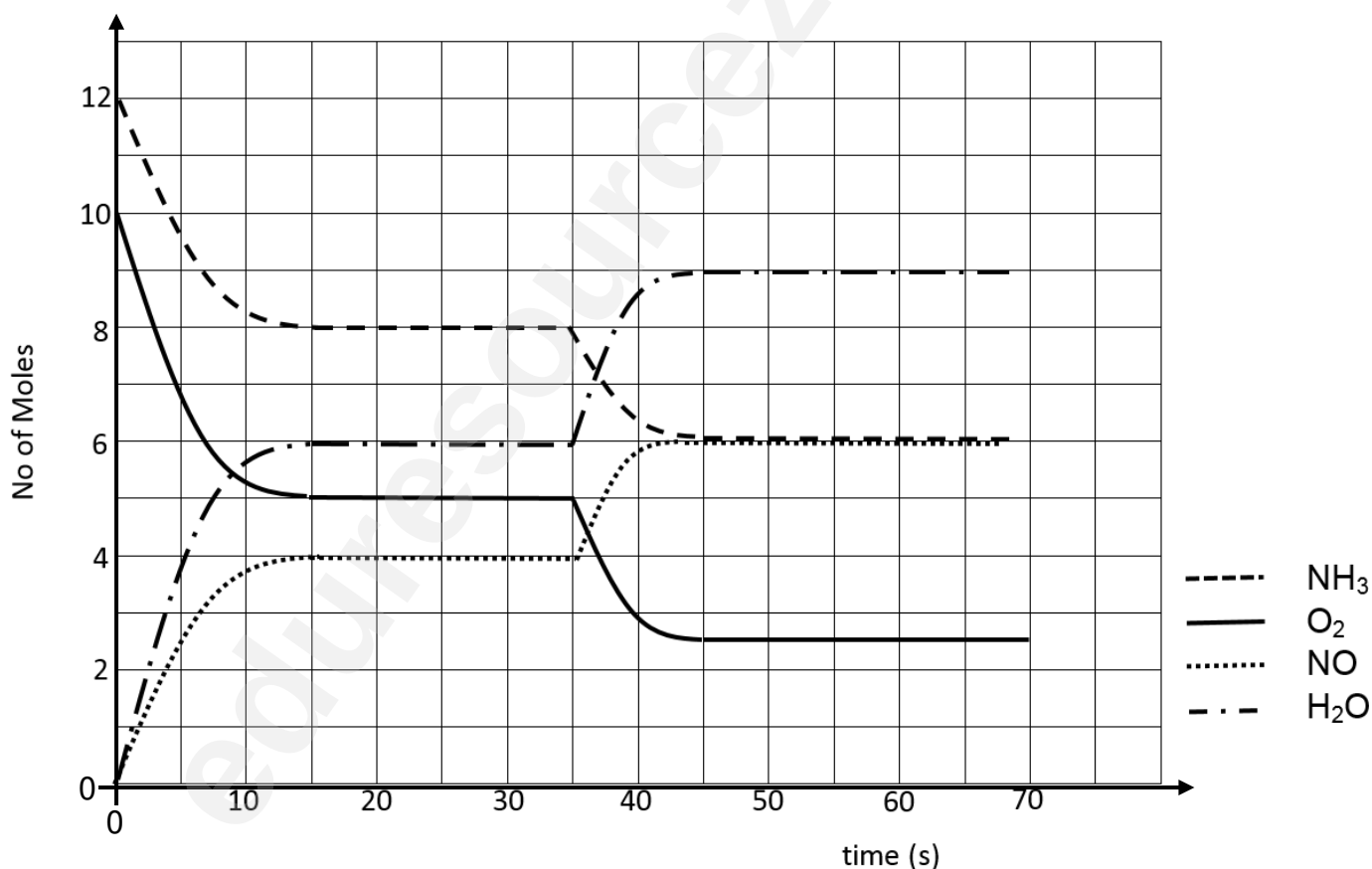
CHEMICAL EQUILIBRIUM

The first stage in the Ostwald process used in the manufacture of nitric acid involves the catalytic oxidation of ammonia. The balanced chemical equation for this reaction is given below.



- 4.1 State Le Chatelier's Principle. (2)
- 4.2 What volume change must be made to the reaction container so that a high yield of products is obtained? Explain by referring to Le Chatelier's principle. (4)

Ammonia and oxygen were added to a reaction vessel which was then sealed. The gases reacted and dynamic chemical equilibrium was reached. The temperature was changed at 35 s, after which the system was allowed to reach equilibrium for the second time. The graph below represents the changes in the number of moles of the reactants and products for this reaction with time.



- 4.3 At what time did the above reaction reach equilibrium for the first time? (1)
- 4.4 What temperature change (INCREASE or DECREASE) was made to the system at 35 s? (1)
- 4.5 Explain why the temperature change made at 35 s would be both an advantage and a disadvantage in industry. (4)

4.6 More moles of oxygen (O_2) are then added to the system at 70 s.



State how each of the following would be affected;

Choose from INCREASES, DECREASES or NO CHANGE.

4.6.1 The rate of the reverse reaction. (1)

4.6.2 The yield of NO. (1)

4.6.3 The equilibrium constant, K_c . (1)

4.7 The ammonia used in the Ostwald process is prepared by the reaction of hydrogen and nitrogen as shown in the following balanced chemical equation:



2,8 mol of $N_2(g)$ and 8,7 mol $H_2(g)$ were injected into a $0,5 \text{ dm}^3$ reaction vessel which was then sealed and allowed to reach equilibrium at 470°C . When equilibrium was reached it was found that the concentration of $NH_3(g)$ was $1,2 \text{ mol}\cdot\text{dm}^{-3}$.

4.7.1 Write down the expression for the equilibrium constant, K_c , for this reaction. (2)

4.7.2 Calculate the equilibrium constant (K_c) at 470°C . Label your work clearly. (7)

4.7.3 What information does your answer for Question 4.7.2 give regarding the expected yield of products (HIGH or LOW) in this reaction? (1)

[25]

QUESTION 5

ACIDS AND BASES (1)

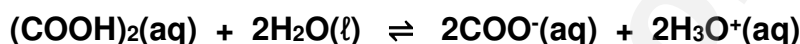
5.1 Hydrochloric acid (HCl) is formed when hydrogen chloride (HCl) gas is dissolved in water.

5.1.1 Write down a balanced equation for the ionisation of hydrogen chloride in water. (2)

5.1.2 Hydrochloric acid is present in the stomach. Milk of magnesia is often taken when someone has heartburn. Milk of magnesia is a suspension of $\text{Mg}(\text{OH})_2$.

Write a balanced chemical equation to show how $\text{Mg}(\text{OH})_2$ reacts with HCl. (3)

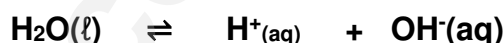
5.2 Oxalic acid ionises in water as shown in the balanced chemical equilibrium equation below.



The equilibrium constant (K_a) for this ionisation reaction is $5,4 \times 10^{-2}$.

5.2.1 Is oxalic acid a STRONG acid or a WEAK acid? (1)

5.2.2 Consider the equations given below for the dissociation of the salt sodium oxalate, $(\text{COONa})_2$ in water and for the ionisation of water.



Consider the interaction between the ions in the aqueous solution of sodium oxalate, $(\text{COONa})_2$ and hence predict whether it would have a pH of LESS THAN 7, EQUAL TO 7 or GREATER THAN 7. Explain your answer fully. (4)

5.2.3 A few crystals of sodium oxalate are dissolved in a solution of oxalic acid. Will the pH of the oxalic acid solution INCREASE, DECREASE or REMAIN THE SAME? Explain the answer by making use of Le Chatelier's principle. (5)

[15]

QUESTION 6 ACIDS AND BASES (2) - CALCULATIONS

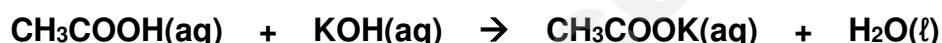
6.1 To prepare 250 cm³ of a 0,4 mol.dm⁻³ standard solution of potassium hydroxide (KOH), Sam dissolves pure grade potassium hydroxide pellets in distilled water.

6.1.1 Define a *standard solution*. (2)

6.1.2 Calculate the mass of potassium hydroxide (KOH) used by Sam to make the standard solution. (4)

6.1.3 The concentration of OH⁻ ions in Sam's standard solution is 0,4 mol.dm⁻³. Calculate the concentration of H₃O⁺ ions in the solution. (3)

During a titration Sam finds that 20 cm³ of ethanoic acid (CH₃COOH) is neutralised by 30 cm³ of 0,4 mol.dm⁻³ potassium hydroxide solution. They react as shown in the following balanced chemical equation:



6.1.4 Ethanoic acid is a weak acid. Give the definition of a *weak acid*? (2)

6.1.5 Calculate the concentration of the ethanoic acid that was neutralised. (5)

Sam has the following indicators available to use in his titration.

Indicator name	pH range
Methyl orange	2,1 – 4,4
Bromothymol blue	6,0 – 7,8
Phenolphthalein	8,3 - 10

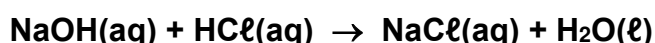
6.1.6 Name the indicator that he should use in the titration of CH₃COOH with KOH. Explain your choice. (4)

6.2 Dylan wants to determine the mass of calcium carbonate in a sea-shell. He initially dissolves the shell in 0,4 dm³ of 0,5 mol.dm⁻³ hydrochloric acid. The balanced chemical equation for the reaction between calcium carbonate and hydrochloric acid is given below.



The other chemicals in the shell do not react with the hydrochloric acid.

The **excess** hydrochloric acid in the above solution is now neutralised by 3,2 g of pure sodium hydroxide pellets. The balanced chemical equation for the reaction between sodium hydroxide and hydrochloric acid is given below.

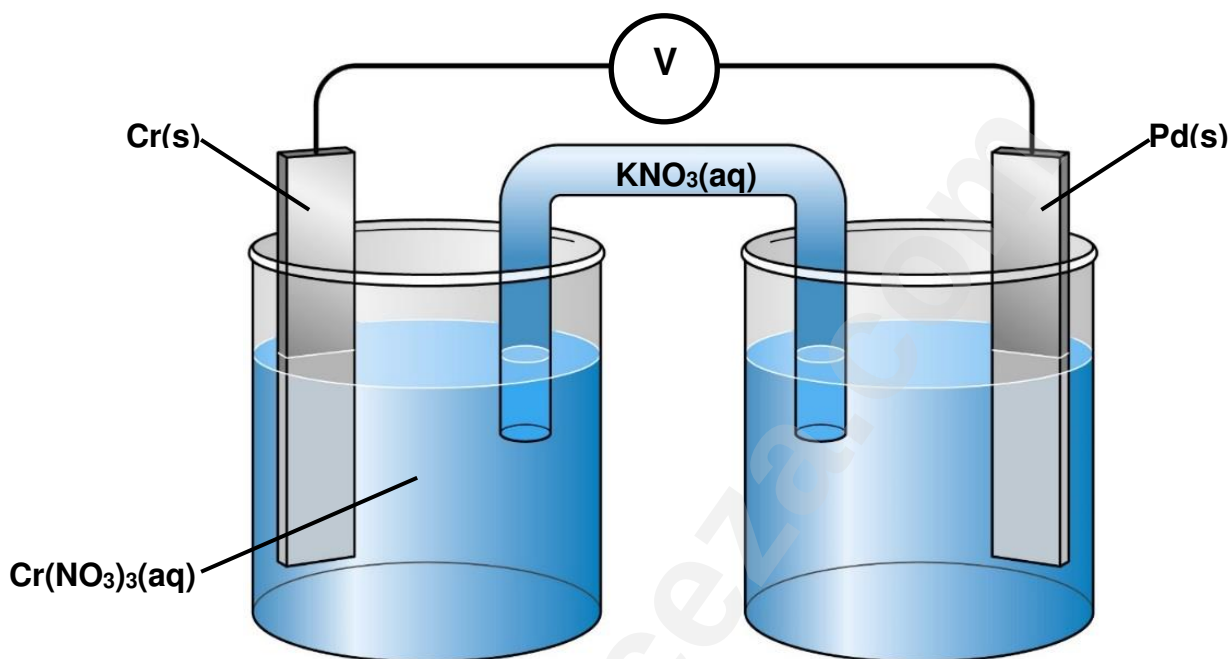


Calculate the mass of CaCO₃ in the shell. (8)

[28]

QUESTION 7 GALVANIC CELL (adapted from DGC Trials 2015)

Ryan sets up a galvanic cell under standard conditions using chromium and palladium electrodes as shown in the diagram below. The standard electrode potential (E^0) for palladium is shown below:



- 7.1 Name a suitable electrolyte for the palladium half-cell. (1)
- 7.2 With reference to the standard hydrogen electrode and all of the necessary standard conditions explain how the standard electrode potential of palladium was obtained. (5)
- 7.3 Write down the half-reaction occurring at the anode of the chromium-palladium cell. (2)
- 7.4 Write a balanced ionic equation for the net cell reaction. (3)
- 7.5 Give the symbol of the reducing agent. (1)
- 7.6 Write down the cell notation for the chromium-palladium cell. Standard conditions and state symbols need not be shown. (3)
- 7.7 Calculate the initial emf of the chromium-palladium cell. (3)
- 7.8 Concentrated sodium hydroxide solution is added to the electrolyte in the palladium half-cell resulting in the formation of an **insoluble precipitate** of palladium hydroxide.
 - 7.8.1 State what happens to the emf of the cell.
Choose from INCREASES, DECREASES, or REMAINS THE SAME. (1)
 - 7.8.2 Explain your answer to Question 7.8.1 above. (2)

[21]

QUESTION 8 ELECTROLYSIS (Adapted from St John's College Prelim)

Electroplating is one of the most common applications of electrolysis. In an investigation, students set out to establish the relationship between current strength and the mass of copper deposited onto copper wire mesh. The apparatus used by the students is illustrated below.

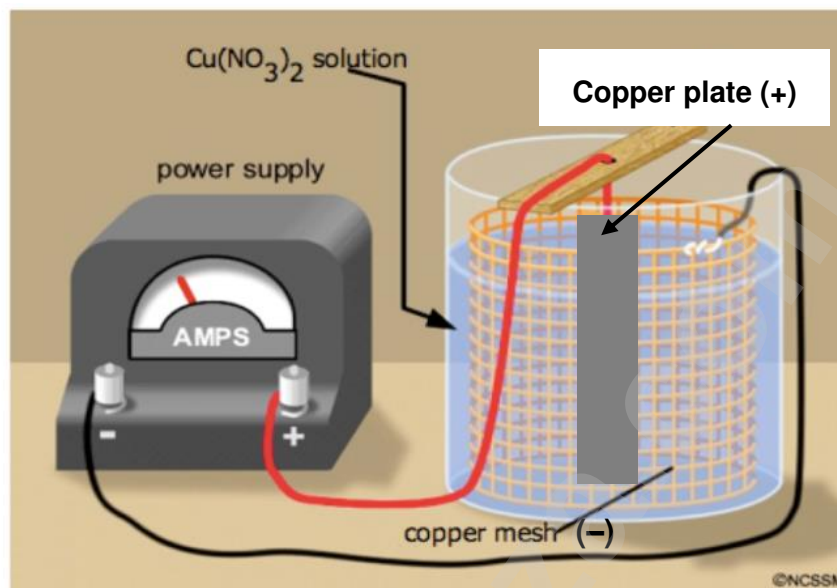


Figure 1: The experimental setup.

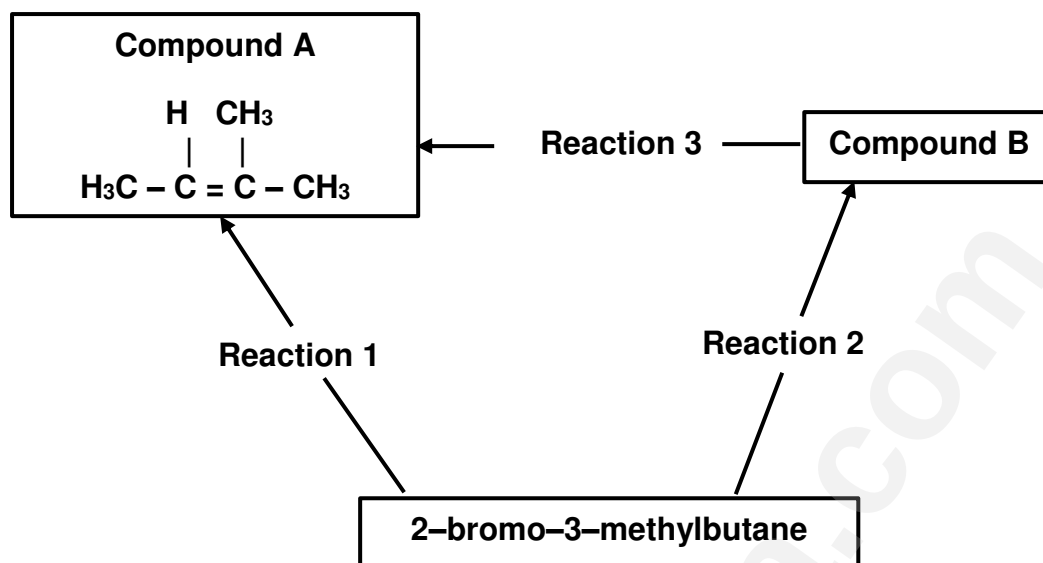
The results that the students obtained from the investigation are tabulated below.

Current (A)	Mass of copper deposited (g)
0,66	0,06
0,82	0,09
0,96	0,12
1,13	0,14
1,26	0,17
1,5	0,22

- 8.1 State the energy conversion which takes places in an electrolytic cell. (2)
- 8.2 Write an equation to represent the half-reaction taking place on the wire mesh. (2)
- 8.3 Suggest a suitable hypothesis for this investigation. (2)
- 8.4 What is the dependent variable in this investigation? (1)
- 8.5 On the graph paper supplied on the **Answer Sheet**, plot a graph to show the relationship between the current strength and the mass of the copper deposited. (7)
- 8.6 Explain why the relationship between the variables cannot be described as "directly proportional". (1)
- 8.7 Use you graph to determine the minimum current required to start the electroplating process. (2)

QUESTION 9 ORGANIC (1)

The flow diagram below shows how two organic compounds, A and B, can be made from 2-bromo-3-methylbutane.



- 9.1 Name the homologous series to which:
- 9.1.1 2-bromo-3-methylbutane belongs. (1)
- 9.1.2 Compound A belongs. (1)
- 9.2 Draw the structural formula of 2-bromo-3-methylbutane. (4)
- 9.3 Reaction 1 takes place in a hot concentrated solution of NaOH in an **ethanol solvent**.
- 9.3.1 Name the type of reaction which takes place. (1)
- 9.3.2 Give the IUPAC name of compound A. (3)
- 9.4 Reaction 2 takes place in a warm **aqueous** alkali solution.
- 9.4.1 Name the type of reaction which takes place. (1)
- 9.4.2 Give the condensed structural formula of compound B. (3)
- 9.5 Using molecular formulae, write a balanced equation for the combustion of compound A in excess oxygen. (3)
- 9.6 Matthew prepares butyl methanoate in the laboratory by gently heating methanoic acid with an alcohol in the presence of a few drops of concentrated sulphuric acid.
- 9.6.1 Draw the structural formula of butyl methanoate. (2)
- 9.6.2 Give the IUPAC name of the alcohol used to produce butyl methanoate. (2)
- 9.6.3 Give the chemical formula of the inorganic product of this reaction. (1)
- 9.6.4 Give the definition of *isomers*. (2)
- 9.6.5 Give the IUPAC name of a positional isomer of butyl methanoate. (2)
- 9.6.6 Give the IUPAC name of a functional isomer of butyl methanoate. (2)

QUESTION 10 ORGANIC (2)

Jason prepares samples of chain isomers **pent-2-ene** and **2-methylbut-2-ene**. He mixes up the sample bottles before he has labelled them. Both compounds are colourless liquids. In order to identify each sample, he determines the boiling point of each under the same conditions. His results are shown in the table.

Sample	Boiling point (°C)
X	39
Y	30

10.1 Which sample (X or Y) is pent-2-ene? (1)

10.2 Explain your answer to Question 10.1 by referring to the intermolecular forces and the factors influencing their strength. (4)

In a separate experiment Jason mixes up samples of pent-2-ene and pentane.

10.3 Describe a chemical test that Jason could perform to distinguish between pent-2-ene and pentane. (3)

[8]

Total: 200 marks

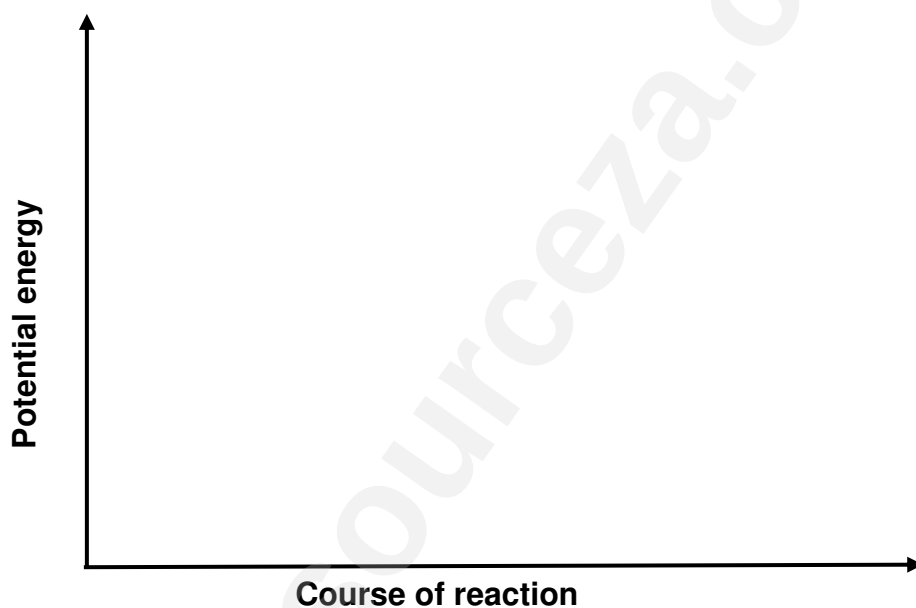
PHYSICAL SCIENCES: PAPER 2

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ANSWER SHEET

QUESTION 3.1



Question 8.5

