THE KING'S SCHOOL

2016
Higher School Certificate
Trial Examination

Chemistry

Disclaimer:
This is a Trial HSC Examination only. It does not reflect the format and topics of the HSC Examination designed by the NSW Board of Studies for the respective sections.

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Board approved calculators may be used
- Write using black pen
- Draw diagrams using pencil
- Write your student number at the top of EVERY page
- Use the Multiple Choice Response sheet provided for your answers to Part A
- A Data Sheet and Periodic Table is provided
- Show all relevant working in questions involving calculations

Total marks – 100

Section I - Pages 2 – 23
Total marks (75)
This section has two parts, Part A and Part B

Part A – 20 marks
Attempt Questions 1 – 20
Allow about 35 minutes for this part

Part B - 55 marks
Attempt questions 21 – 31
Allow about 1 hour 40 minutes for this part

Section II - Pages 25 - 29
Total marks (25)
Attempt ONE question from Questions 32 - 33
Allow about 45 minutes for this part

This paper MUST NOT be removed from the examination room

Section I

Part A
Total marks (20)
Attempt questions 1 – 20
Allow about 35 minutes for this part

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1. Which of the following isotopes is most likely to decay by beta emission?

    A   Oxygen - 18
    B   Sodium - 22
    C   Carbon -12
    D   Nitrogen - 14

2. Identify the product formed when ethanol is heated under reflux in the presence of concentrated sulfuric acid.

    A   Ethylene
    B   Ethane
    C   Ethanoic acid
    D   Polyethylene

3. What is the name of the product formed when bromine, Br_2, reacts with but-2-ene?

    A   1,2 - dibromobutane
    B   2,3 - dibromobutane
    C   1,4 - dibromobutane
    D   2,2 - dibromobutane

4. In an experiment, 0.051 mol of sodium hydroxide, NaOH, reacted completely with 0.017 mol of citric acid, $C_6H_8O_7$.

    Which one of the following equations correctly represents the reaction between citric acid and sodium hydroxide solution?

    A $3NaOH\ (aq)\ +\ C_6H_8O_7\ (aq)\ \rightarrow\ 3NaC_6H_7O_7\ (aq)\ +\ 3H_2O\ (l)$
    B $2NaOH\ (aq)\ +\ C_6H_8O_7\ (aq)\ \rightarrow\ Na_2C_6H_6O_7\ (aq)\ +\ 2H_2O\ (l)$
    C $3NaOH\ (aq)\ +\ C_6H_8O_7\ (aq)\ \rightarrow\ Na_3C_6H_5O_7\ (aq)\ +\ 3H_2O\ (l)$
    D $4NaOH\ (aq)\ +\ C_6H_8O_7\ (aq)\ \rightarrow\ Na_4C_6H_4O_7\ (aq)\ +\ 4H_2O\ (l)$

5. The switch in the galvanic cell below may be closed to allow a current to flow through the circuit:
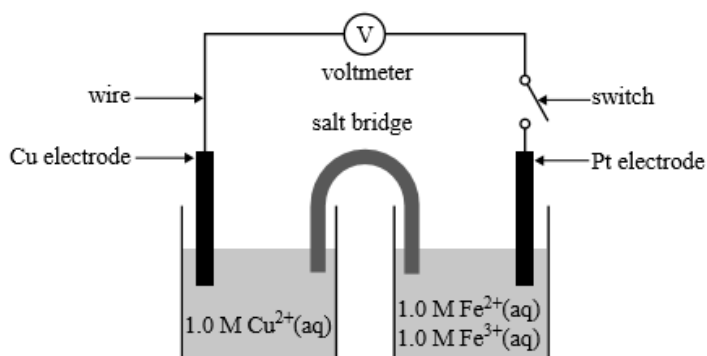
Which of the following best describes the direction of electron flow in the external circuit and the maximum predicted cell voltage measured at the voltmeter when the switch is closed?

	Direction of electron flow is towards the	Maximum predicted cell voltage is
A	Cu electrode	0.43 V
B	Cu electrode	1.11 V
C	Pt electrode	0.43 V
D	Pt electrode	1.11 V

6. What is the correct systematic name for the following compound?
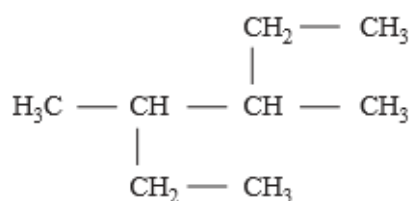
A   2-ethyl-3-methylpentane
B   3-methyl-4-ethylpentane
C   3,4-dimethylhexane
D   2,3-diethylbutane

7. When hydrochloric acid is added to aluminium sulfide, the highly toxic gas hydrogen sulfide is evolved.

$$Al_2S_3 \ (s) + 6HCl \ (aq) \rightarrow 2AlCl_3 \ (aq) + 3H_2S \ (g)$$
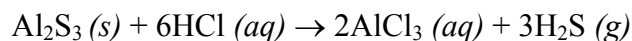
If excess hydrochloric acid is added to 0.200 mol of aluminium sulfide, then the volume of hydrogen sulfide produced at 25°C and 100 kPa will be:

A   2.48 L
B   4.96 L
C   7.44 L
D   14.9 L

8. The graph shows the change in pH as a base is added to an acid during a titration.
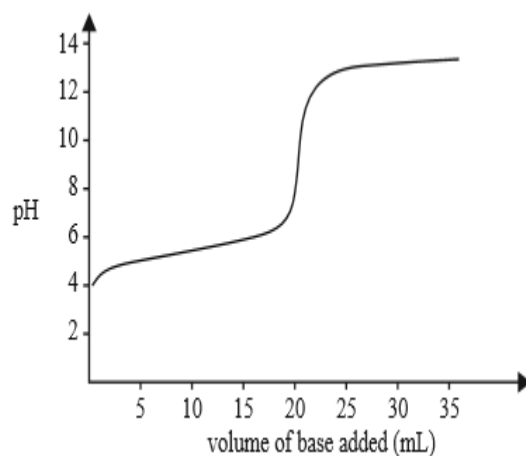
Which of the listed indicators would be LEAST suitable to detect the end point of this neutralisation?

A   Methyl orange
B   Litmus
C   Bromothymol blue
D   Phenolphthalein

9. In which one of the following compounds is sulfur in its lowest oxidation state?

    A Al_2S_3
    B SO_3
    C SO_2
    D HSO_4^-

10. A concentration–time graph for the equilibrium represented by the equation is shown below.

    $$2NOCl\ (g)\ \rightleftharpoons\ 2NO\ (g)\ +\ Cl_2\ (g) \qquad \Delta H \text{ is positive}$$
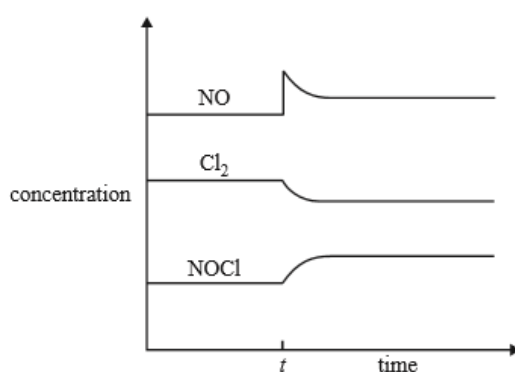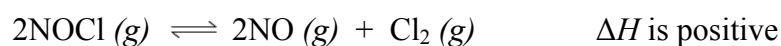
    What event occurred at time t to cause the change in the equilibrium concentrations?

    A   The pressure was increased at a constant temperature
    B   Additional NO gas was added at a constant temperature and volume
    C   A catalyst was added
    D   The temperature was increased at a constant volume

11. The products of a condensation polymerisation are:

    A   polymer and water
    B   polymer and oxygen
    C   polymer and hydroxide
    D   polymer only

12. A student determined the heat of combustion of ethanol, using the equipment below.
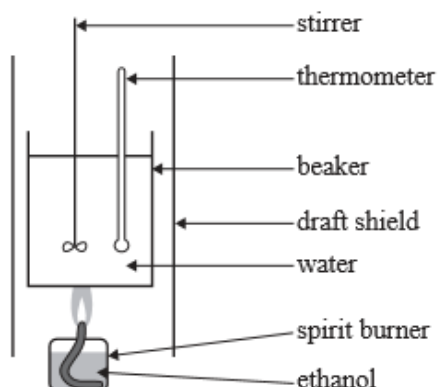
The student made the following measurements:

Mass of water in beaker = **100.0 g**
Amount of ethanol combusted = **0.92 g**
Initial temperature of water = **15.0°C**
Final temperature of water = **55.0°C**

The heat of combustion calculated using the student's data is:

A   16.7 kJ mol^{-1}
B   18.2 kJ mol^{-1}
C   334 kJ mol^{-1}
D   836 kJ mol^{-1}

13. Identify the amphoteric oxide.

A   calcium oxide
B   carbon dioxide
C   sulfur dioxide
D   aluminium oxide

Questions 14 and 15 refer to the following information

The graph below refer to the following gaseous reaction, where the co-efficients a, b, c and d represent the moles of gases reacting and forming.

$$aA\,(g)\;+\;bB\,(g)\;\rightleftharpoons\;cC\,(g)\;+\;dD\,(g)$$
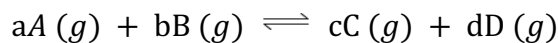
The effect of increasing pressure and temperature on the equilibrium yield of the products is shown in the graph below.
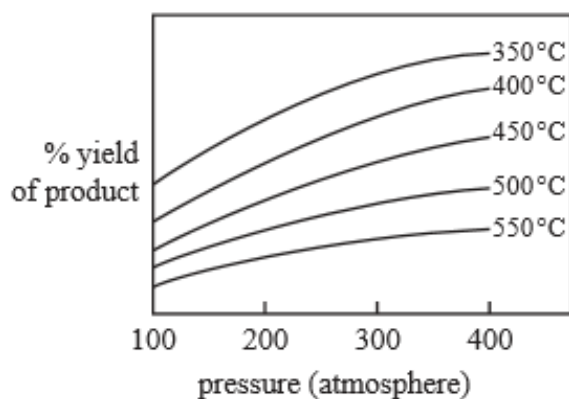
14. Which one of the following statements about the relative number of reactant and product molecules in the balanced equation is correct?

   A   The number of reactant molecules is equal to the number of product molecules.
   B   The number of reactant molecules is greater than the number of product molecules.
   C   The number of reactant molecules is less than the number of product molecules.
   D   The relative number of reactant and product molecules cannot be determined from the data provided.

15. Which one of the following statements about this gaseous reaction is correct?

   A   The reaction is exothermic because the yield increases as the temperature increases.
   B   The reaction is exothermic because the yield decreases as the temperature increases.
   C   The reaction is endothermic because the yield increases as the temperature increases.
   D   The reaction is endothermic because the yield decreases as the temperature increases.

16. A buffer solution was prepared by mixing equal moles of sodium acetate (ethanoate) and acetic acid in water.

A student made the following statements about this buffer system:

I	Addition of a few drops of concentrated nitric acid will produce more acetic acid molecules.
II	The sodium ions play a significant role in the buffering action.
III	Addition of water to the buffer will increase its buffering ability.
IV	Addition of a few drops of sodium hydroxide will produce more acetate ions.

The correct statements are:

A   I only
B   I and II
C   II and III
D   I and IV

17. A sulfuric acid solution has a concentration of 5×10^{-4} mol L^{-1}. What is the pH of this solution, assuming the acid has completely ionised?

A   3.0
B   3.3
C   3.6
D   4.0

18. Identify the synthetic polymer:

A   cellulose
B   cotton
C   wool
D   nylon

19. The Haber process for producing ammonia was developed in the early Twentieth Century. What was the major advantage of its development?

A   A government sold the process to other governments.
B   The inventor sold the process for a great deal of money.
C   It has provided a source of nitrogen for farming and industry.
D   It has provided jobs for many who were unemployed.

20. Ammonia is produced from hydrogen and nitrogen according to the equation:

$$N_2 \text{ (g)} + 3H_2 \text{ (g)} \rightleftharpoons NH_3 \text{ (g)}$$
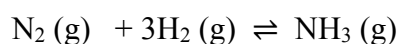
The graph shows the yield of ammonia produced at 200°C and 100 kPa:
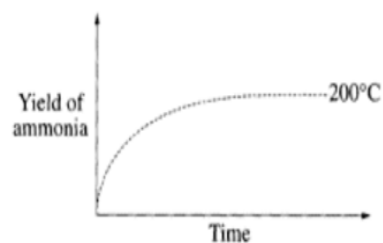
Which graph shows a correct comparison of the yield of ammonia produced at a temperature of 400°C with the yield produced at 200°C and 100 kPa?

A
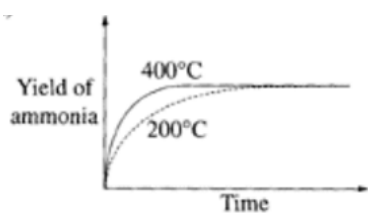
B
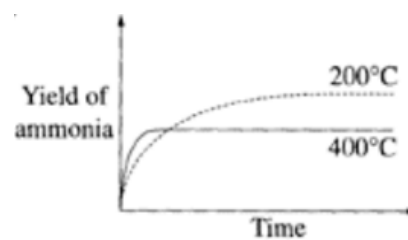
C
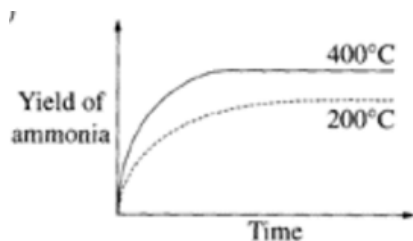
D
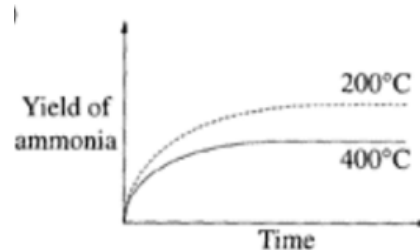
End of Part A

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Part B
Total marks (55)
Attempt ALL questions
Allow about 1 hours 40 minutes for this part

Answer the questions in the spaces provided

Show all relevant working in questions involving calculations.

Question 21 (6 marks)   **Marks**

(a)   Dacron is the trade name of a polyester used in making clothes and water bottles. Part
      of its structural formula is given below: **2**
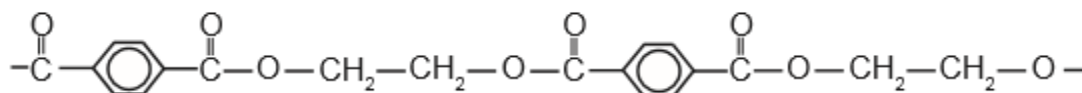
      Draw the structural formulae for the two monomers that react to form this polymer.

(b)   Cellulose is a natural biopolymer found in plants. Analyse the relationship between the
      structure of cellulose, its properties and its uses.   **4**

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Question 22 (7 marks)   **Marks**

A group of Chemistry students analysed household cloudy ammonia (a detergent used in domestic cleaning). A back titration was used because the detergent contained ammonia, which is very volatile.

The teacher's instructions for the analysis were as follows:

Step	*Instructions*
1	Pipette 25.00 mL of the cloudy ammonia into a 250.00 mL volumetric flask.
2	Add 100.00 mL of hydrochloric acid, which is in excess.
3	Make the volume up to the 250 mL mark with deionised water. Label this 'Solution A'.
4	Fill a burette with sodium hydroxide solution.
5	Transfer a 20.00 mL aliquot of Solution A (from Step 3) to a titration flask. Add indicator and titrate with the sodium hydroxide solution.
6	Repeat Step 5 until three appropriate results are obtained.

The relevant equations for this analysis are as follows:

$$NH_3 \ (aq) + HCl \ (aq) \rightarrow NH_4Cl \ (aq)$$

$$HCl \ (aq) + NaOH \ (aq) \rightarrow NaCl \ (aq) + H_2O \ (l)$$
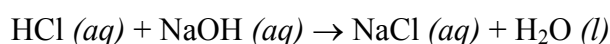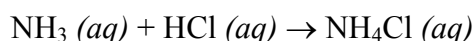
Measurement	*Result*
Volume of cloudy ammonia sample	25.00 mL
Volume of HCl added to cloudy ammonia	100.00 mL
Concentration of HCl added to cloudy ammonia sample	0.5866 mol L^{-1}
Total volume of Solution A	250.00 mL
Volume of aliquot of Solution A used in each titration	20.00 mL
Concentration of NaOH solution	0.1492 mol L^{-1}
Mean titre	22.75 mL

(a)   Calculate the amount, in moles, of hydrochloric acid initially added to the undiluted ammonia sample.   **1**

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Question 22 continues on page 13

Question 22 (continued) **Marks**

(b) Calculate the amount, in moles, of excess hydrochloric acid in a 20.00 mL aliquot of the diluted solution (Step 5). **1**

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(c) The manufacturer claims that the detergent contains 23 g L^{-1} ammonia.

Use the students' experimental results to calculate:

(i) The amount, in moles, of HCl that reacted with the ammonia in the volumetric flask. **2**

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(ii) The amount, in moles, of ammonia initially pipetted into the 250 mL volumetric flask. **1**

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(iii) The concentration, in g L^{-1}, of NH_3 in the cloudy ammonia sample. **1**

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(iv) Provide ONE explanation for any difference between the students' results and the manufacturer's claim. **1**

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Question 23 (6 marks)   **Marks**

(a)   Explain, using appropriate equations, why the dihydrogen phosphate ion is classified as
      amphiprotic.   **2**

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(b)   Explain, using an appropriate equation, why an aqueous solution of potassium
      dihydrogen phosphate has a pH below 7.   **2**

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(c)   Explain what is meant by the term "an amphoteric oxide" and give an appropriate
      example.   **2**

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Question 24 (4 marks)   **Marks**

The flow chart shows the formation of an ester and water.
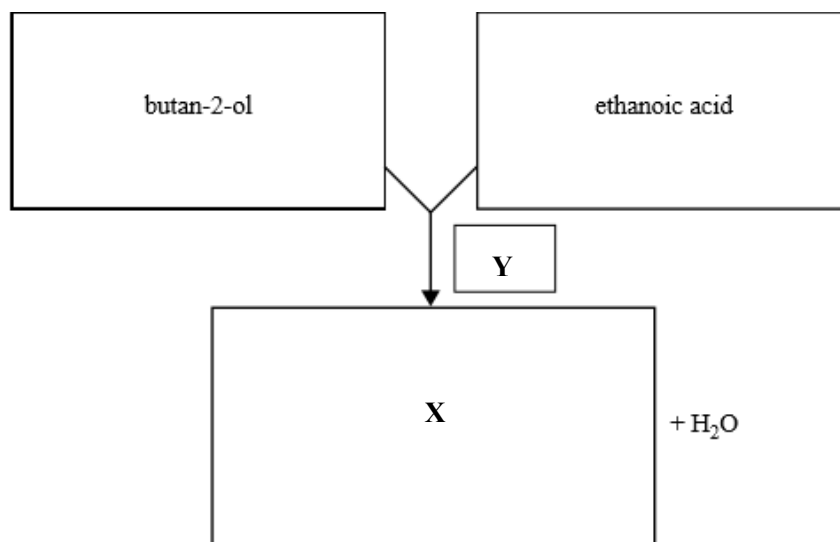
(a)   Draw a structural formula for compound **X**.   **1**

(b)   Identify **Y** and outline the roles of **Y** in this reaction.   **3**

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Question 25 (3 marks)   **Marks**

Identify a branch of chemistry.

Describe the range of roles undertaken by scientists working in this branch of chemistry and
identify the specific role of one identified scientist.   **3**

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Question 26 (6 marks)   **Marks**

(a)   Define a buffer solution.   **1**

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(b)   Analyse how an identified buffer system is maintained in a natural environment.
      Include appropriate equations in your answer.   **5**

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Question 27 (3 marks)   **Marks**

The graph shows changes in pH for the titrations of equal volumes of solutions of two monoprotic acids, *Acid 1* and *Acid 2*.

Explain the differences between *Acid 1* and *Acid 2* in terms of their relative strengths and
concentrations.   **3**

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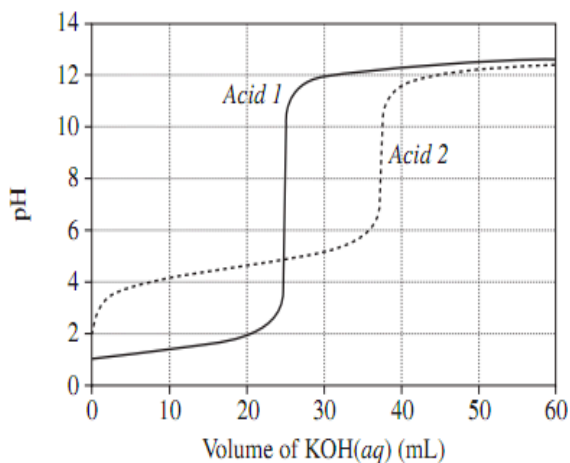
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Question 28 (6 marks)

Marks

Chemists can assist in reversing or minimising the environmental problems caused by technology and the human demand for products and services.

With reference to this statement, assess the need for chemists to collaborate when monitoring the environmental impact of a <u>named electrochemical cell</u>.

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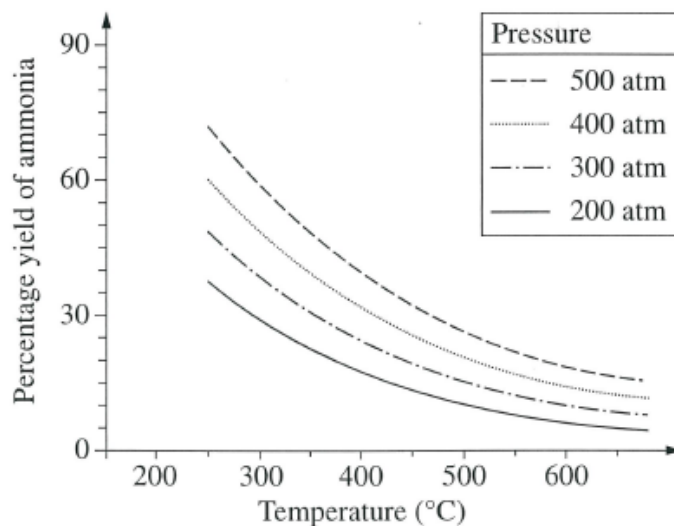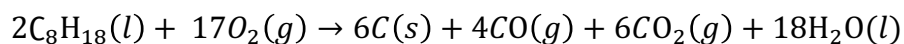
Question 29 (5 marks)   **Marks**

The graph shows the percentage yield of ammonia produced from nitrogen and hydrogen at different temperatures and pressures.

The Haber process is the main industrial procedure for the production of ammonia. Explain the conditions used in the Haber process with reference to the graph.   **5**

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Question 30 (4 marks)   **Marks**

Under the conditions of low oxygen levels, octane can undergo incomplete combustion according to the following chemical equation:

$$2C_8H_{18}(l) + 17O_2(g) \rightarrow 6C(s) + 4CO(g) + 6CO_2(g) + 18H_2O(l)$$

(a)   Explain the need to monitor this process.   **2**

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(b)   Calculate the mass of soot (C(s)) produced if 4.2 moles of octane are combusted in this way.   **2**

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Question 31 (5 marks)   **Marks**

A student performed a first-hand investigation to determine the quantitative relationship between heat of combustion and molar mass of alkanols. The student did this by burning different alkanols to heat water as shown in the diagram below. The calculated heats of combustion for four of the alkanols are given in the table.
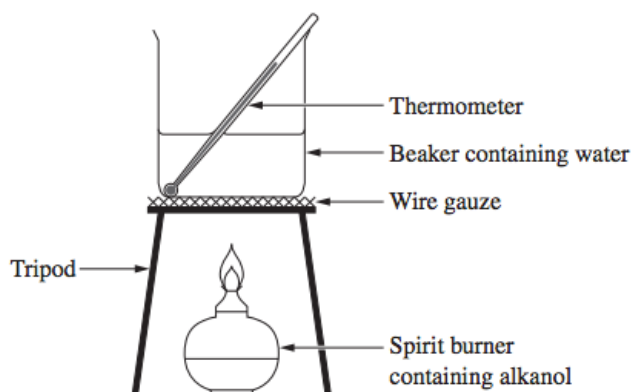
Alkanol	Molar mass $(g\ mol^{-1})$	Calculated heat of combustion $(kJ\ mol^{-1})$	Theoretical heat of combustion $(kJ\ mol^{-1})$
methanol	32	150	726
ethanol	46	950	1367
propan-1-ol	60	1500	2021
butan-1-ol	74	2250	2676

Question 31 (continued)   **Marks**

(a)   Using the grid, graph both the calculated and the theoretical heat of combustion against
        the molecular mass of the alkanols.   **3**

Heat of combustion versus molecular mass

**Heat of
combustion
(kJ mol⁻¹)**
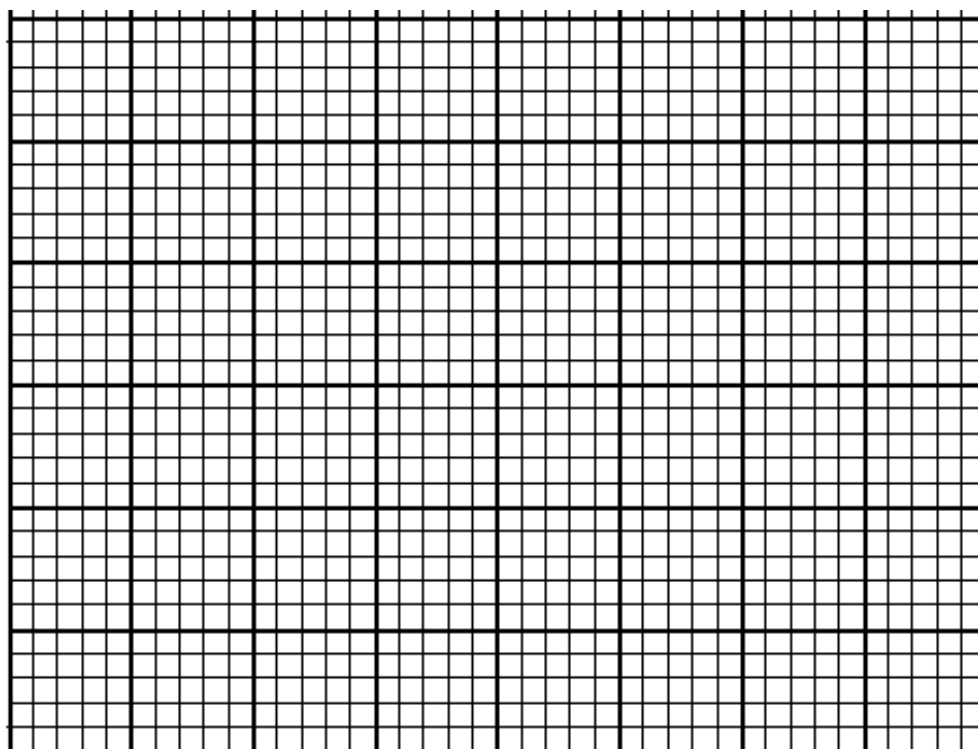
**Molecular mass
(g mol⁻¹)**

(b)   Discuss the validity of the student's investigation.   **2**

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End of Section I

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Chemistry

Section II

25 marks
Attempt ONE question from Questions 32– 33
Allow about 45 minutes for this Section

Answer the question in the writing booklet provided. Extra writing booklets are available.

Show all relevant working in questions involving calculation.

		Pages
Question 32	Industrial Chemistry ………………………………………….	**24**
Question 33	Shipwrecks, Corrosion and Conservation ……………………	**29**

Question 32 (25 marks)   **Marks**

(a) The diagram shows processes involved in the industrial production of sodium carbonate.
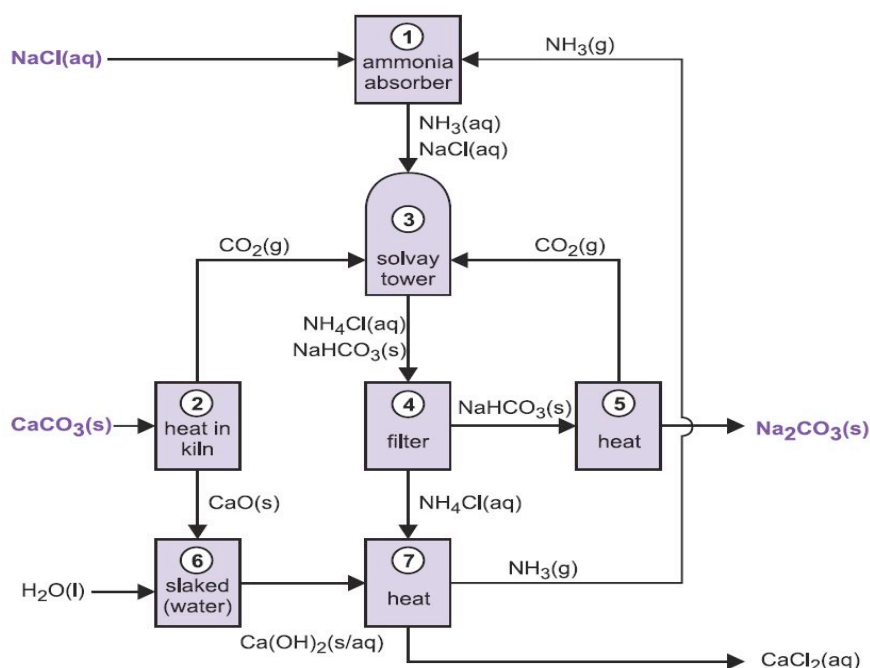
(i)   Identify the raw materials needed for the production of sodium carbonate.   **1**

(ii) Write an equation for the process involved in the recovery of ammonia.   **1**

(iii) Explain why Solvay plants are often located near the ocean.   **2**

(b) Sulfuric acid is an important industrial chemical.

(i)   Safety precautions must be observed when using and transporting sulfuric acid.

Discuss this statement, referring to the use of sulfuric acid in the laboratory and referring to its transport.   **2**

(ii) "The contact process in the production of sulfuric acid requires careful monitoring to produce an optimal yield of sulfuric acid."

Justify this statement.   **3**

Question 32 continues on page 27

(c) Consider the reaction shown in the following equation:

$2NO(g) + Br_2(g) \rightleftharpoons 2NOBr(g)$ $\Delta H = -16.1$ kJ mol^{-1}, $Kc = 1.3 \times 10^{-2}$ at 1000 K
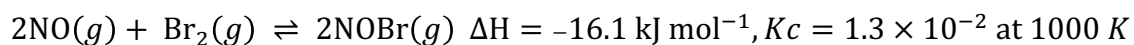
   (i) Write an expression for the equilibrium constant for this reaction.

1

   (ii) 10.0 mol of NOBr, 10.0 mol of NO and 5.0 mol of Br$_2$ were placed in a 1.0 L container at 1000 K.

Predict in which direction the reaction will proceed. Justify your answer. Show all relevant working.

2

   (iii) A mixture of NO, NOBr and Br$_2$ is initially at equilibrium.

The following graph shows how the **rate** of formation of NOBr in the mixture changes when the volume of the reaction vessel is decreased at time t$_1$.
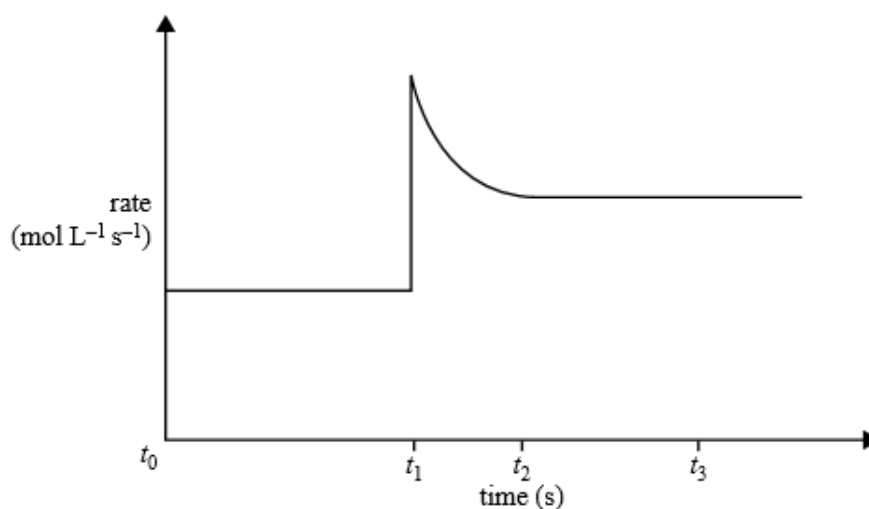
Explain the shape of the graph:

2

   • between t$_0$ and t$_1$
   • at t$_1$
   • between t$_1$ and t$_2$

Marks

(d)   The diagram below shows an electrolytic cell used in a significant industrial process you have studied.
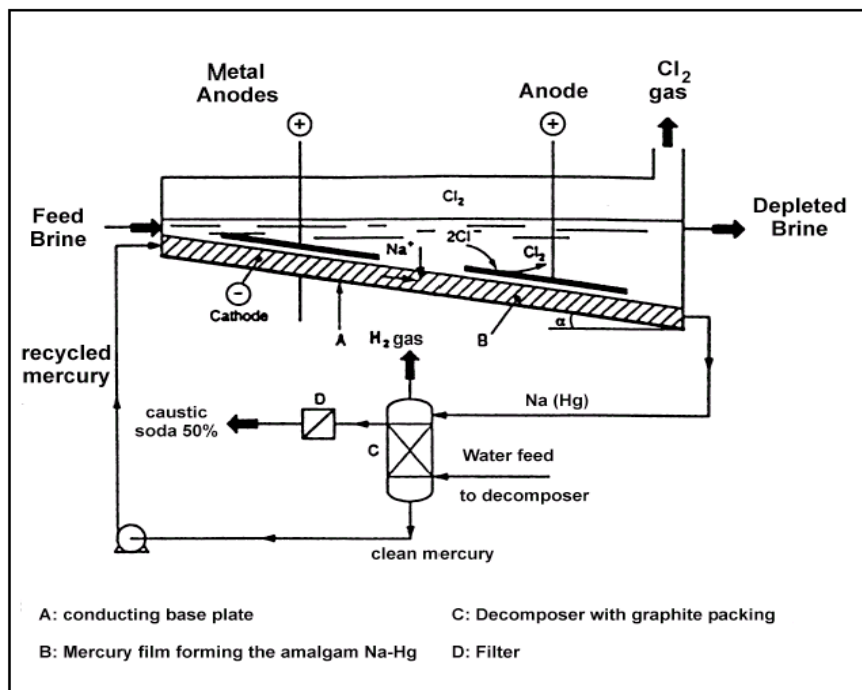
Figure 2.3: Flow diagram of mercury cell technology

(i)   Write half-equations for the reaction which occurs at the: **2**

   • anode
   • cathode

(ii) Explain why newly constructed electrolysis units, producing the same products, do not use the technology as shown in the diagram above.   Refer to the differences in the electrolysis units in your response.   **2**

(e)   Soap can be described as a surfactant and as an emulsifier.

(i)   Describe a first-hand investigation you performed to demonstrate the effect of soap as an emulsifier.   **2**

(ii) *The structure of soap allows it to act as an emulsifier, as a surfactant and as a cleaning agent.*

   Assess this statement.   **5**

End of Question 32

Question 33 – Shipwrecks, Corrosion and Conservation (25 marks)   **Marks**

(a)   The work of Sir Humphry Davy (1778-1829) had great significance in the development of our modern understanding of the electrical nature of matter.
Discuss this statement.   **4**

(b)   Both mild and structural steels corrode rapidly in marine environments. As a result, aluminium, galvanised iron and stainless steel are preferred for construction where there is risk of corrosion.

       Compare the properties and composition of mild and structural steels, aluminium, galvanised iron and stainless steel which account for their different uses.   **5**

(c)   The Titanic shipwreck has lied at great depth in the Atlantic Ocean since 1912.

       Analyse why scientists initially thought that the Titanic shipwreck would not have been significantly corroded. Use equations for the corrosion processes in your response.   **6**

(d)   The diagram shows apparatus used for an electrolysis experiment, using concentrated potassium iodide solution.
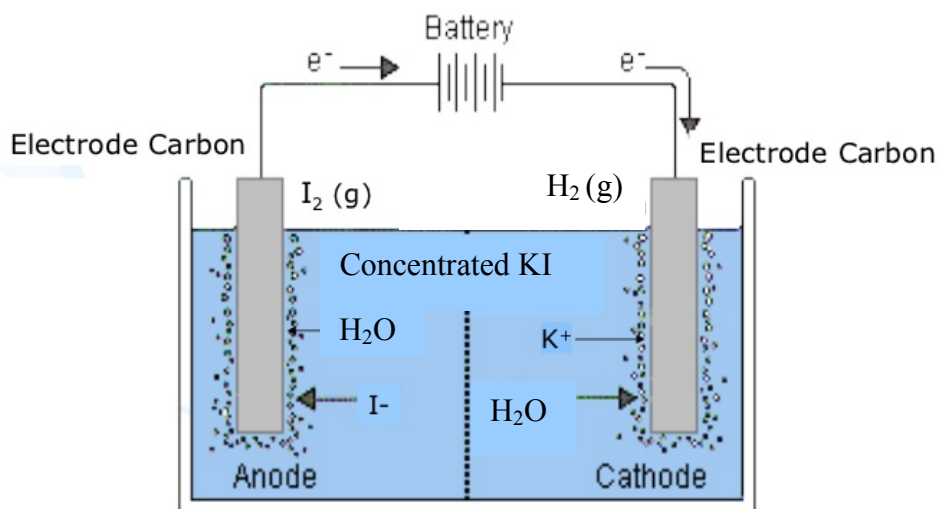
     (i)   Write half-equations for the electrode reactions occurring in the above cell.   **2**

     (ii)   How would the products of the reaction differ if a very dilute solution of potassium iodide had been used instead of the concentrated solution? Explain your response and include an appropriate half-equation.   **2**

(e)   Compare the conservation and restoration techniques used in TWO Australian maritime archaeological projects.   **6**

End of Question 33

End of paper