
Student Number

2010
TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A data sheet and a Periodic Table are provided at the back of this paper
- Use the multiple-choice answer sheet provided at the back of this paper
- Write your Student Number at the top of this page and page 12, on the multiple-choice answer sheet and on the cover of the option answer booklet.

Total marks - 100

Section I Pages 3-21

75 marks
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 21-30
- Allow about 1 hour and 40 minutes for this part

Section II Pages 22-23

25 marks
- Attempt Question 31
- Allow about 45 minutes for this section

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2010 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION CHEMISTRY

Section I
75 marks

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

Use the multiple-choice answer sheet provided for Questions 1-20

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ✗ C ○ D ○

If you have changed your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows:

correct

A ✗ B ✗ C ○ D ○

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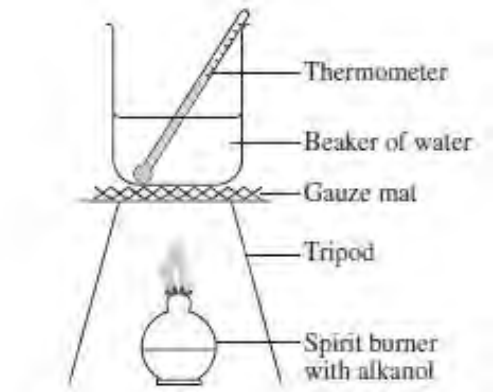
1 The apparatus shown below is used in a first-hand investigation to determine and compare the heat of combustion of three different liquid alkanols.



Which is the independent variable?

(A) Type of alkanol used.

(B) Amount of water used.

(C) Amount of alkanol used.

(D) Temperature change of the water.

2 What type of reaction describes the polymerisation of glucose into cellulose?

(A) Addition

(B) Hydrolysis

(C) Substitution

(D) Condensation

3 Which of the following lists properties of an isotope that would make it suitable for use in medical diagnosis?

	Half-life	***Emission***
(A)	8 days	Beta and gamma rays
(B)	6 hours	Gamma rays only
(C)	6 minutes	Alpha and gamma rays
(D)	Thousands of years	Beta rays only

4 Why is research into synthetic biopolymers attracting great interest?

(A) They decompose more easily than traditional synthetic polymers.

(B) They can be produced more cheaply than traditional synthetic polymers.

(C) They have superior physical properties compared to traditional synthetic polymers.

(D) They have superior chemical properties compared to traditional synthetic polymers.

5 Which of the following changes will always shift this equilibrium reaction to the right?

$$2HI_{(g)} \rightleftharpoons H_{2\,(g)} + I_{2\,(g)} \qquad \Delta H = -52 kJ\ mol^{-1}$$

(A) Adding a catalyst.

(B) Increasing the pressure.

(C) Increasing the temperature.

(D) Adding more of the reactant.

6 Bromine dissolves in unsaturated hydrocarbons and reacts immediately.

Which of the following is the best description of this process?

(A) Bromine is polar and reacts by adding bromine atoms across the double bond.

(B) Bromine is polar and reacts by substituting hydrogen atoms with bromine atoms.

(C) Bromine is non-polar and reacts by adding bromine atoms across the double bond.

(D) Bromine is non-polar and reacts by substituting hydrogen atoms with bromine atoms.

7 Which of the following conditions would produce a radioactive isotope?

(A) Too many atoms in the sample provided.

(B) Too many protons and neutrons in the atom.

(C) Too many electrons in the outer shell of the atom.

(D) Too many electrons for the number of neutrons in the atom.

8 The heat of combustion of ethanol is 1360 kJ mol^{-1}. What mass of ethanol needs to be burnt to raise the temperature of 500 g of water from 20°C to 44°C?

(A) 3.72×10^{-2} g.

(B) 1.70 g.

(C) 8.0×10^{-4} g.

(D) 5.0×10^{3} g.

9 The conjugate base of the acid HSO_4^- is:

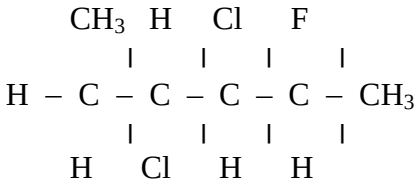
(A) H_2SO_4

(B) SO_4^-

(C) SO_4^{2-}

(D) HSO_4^{2-}

10 What is the IUPAC name of the following compound?



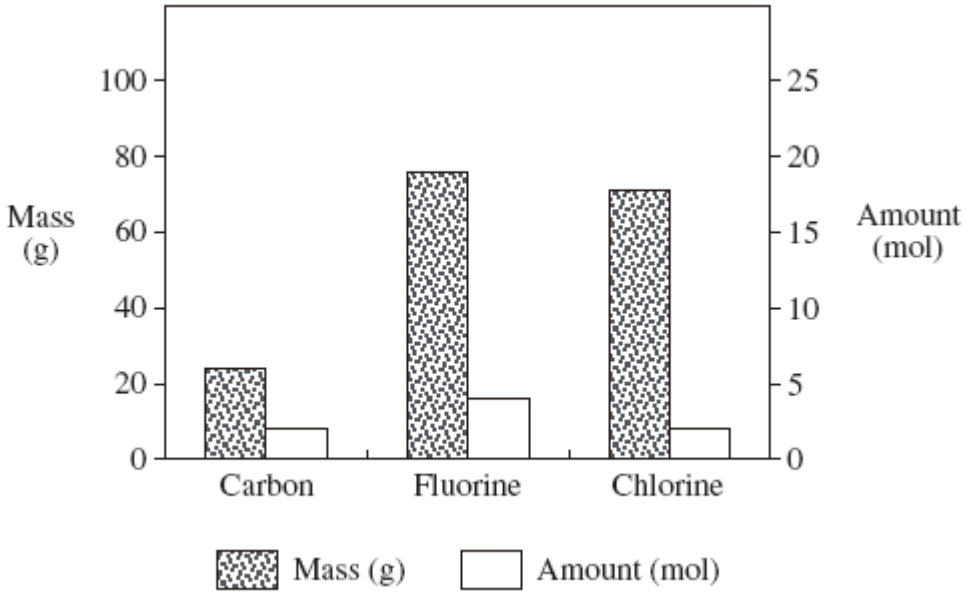
(A) 3,4- dichloro-5-fluorohexane

(B) 5-fluoro-3,4- dichlorohexane

(C) 2-fluoro-3,4- dichlorohexane

(D) 3,4- dichloro-2-fluorohexane

11 The graph shows the mass and amount of carbon, fluorine and chlorine atoms in one mole of a compound.



What is the molecular formula for this compound?

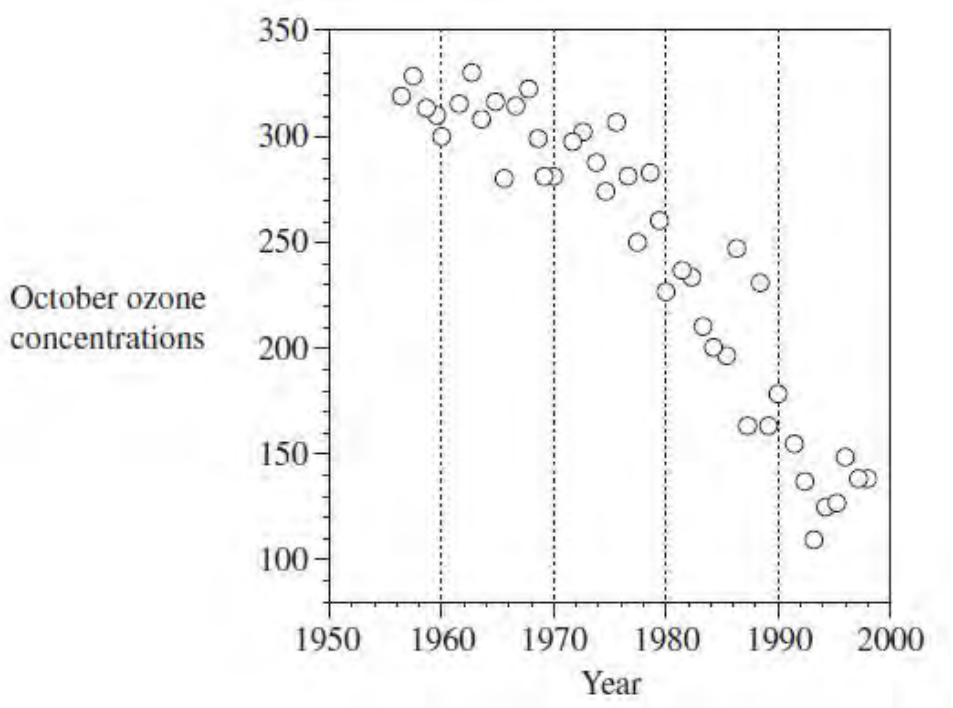
(A) CF_2Cl

(B) CF_2Cl_2

(C) $C_2F_3Cl_3$

(D) $C_2F_4Cl_2$

12 The graph shows October ozone concentrations above Halley Bay in Antarctica between 1956 and 1998.



Based only on the data in the above graph, which of the following is a valid statement about the concentration of ozone above Halley Bay?

(A) It was greater in 1998 than in 1993.

(B) It will be greater in 2004 than in 1998.

(C) The variation in ozone concentration between 1960 and 1970 was due to changes in atmospheric CFC concentrations.

(D) The variation in ozone concentration from one year to the next is due only to changes in atmospheric CFC concentrations.

13 A 2.45 g sample of lawn fertiliser was analysed for its sulfate content. After filtration and drying, 2.18 g of barium sulfate was recovered.

What is the % w/w of sulfate in the lawn fertiliser?

(A) 16.8

(B) 36.6

(C) 46.2

(D) 89.0

14 What volume of water must be added to 60 mL of a 0.001 mol L^{-1} hydrochloric acid solution to change the pH to 5.0?

(A) 180 mL.

(B) 240 mL.

(C) 540 mL.

(D) 5940 mL.

15 What volume of sulfur dioxide, measured at 0°C and 100 kPa pressure, can be absorbed by 0.10 mol of sodium hydroxide solution? (Hint: sodium sulfite is formed)

(A) 1.14 L.

(B) 1.24 L.

(C) 2.27 L.

(D) 4.53 L.

16 The pH of a solution of sulfuric acid was 3.40. This means that in that solution the sulfate ion concentration in moles per litre was:

(A) 4.0×10^{-4}

(B) 2.0×10^{-4}

(C) 8.0×10^{-4}

(D) 2.0×10^{-3}

17 Acid *X* is 0.1 mol L^{-1} hydrochloric acid.

Acid *Y* is 1.0 mol L^{-1} ethanoic acid.

How does acid *X* compare with acid *Y*?

(A) *X* is stronger and more dilute than *Y*.

(B) *X* is weaker and more dilute than *Y*.

(C) *X* is weaker and more concentrated than *Y*.

(D) *X* is stronger and more concentrated than *Y*.

18 In a titration of a strong base with a strong acid, the following procedure was used:

1. A burette was rinsed with water and then filled with the standard acid.
2. A pipette was rinsed with some base solution.
3. A conical flask was rinsed with some base solution.
4. A pipette was used to transfer a measured volume of base solution into the conical flask.
5. Indicator was added to the base sample and it was titrated to the endpoint with the acid.

Which statement is correct?

(A) The calculated base concentration will be correct.

(B) The calculated base concentration will be too low.

(C) The calculated base concentration will be too high.

(D) No definite conclusion can be reached about the base concentration.

19 The dissolution and chemical reaction of carbon dioxide in water are both exothermic reactions.

$CO_2\ (g) \rightleftharpoons CO_2\ (aq)$.

$CO_2\ (aq) + H_2O\ (l) \rightleftharpoons H_2CO_3\ (aq)$.

The dissolution of carbon dioxide in water can be increased by:

(A) decreasing the pressure

(B) decreasing the temperature

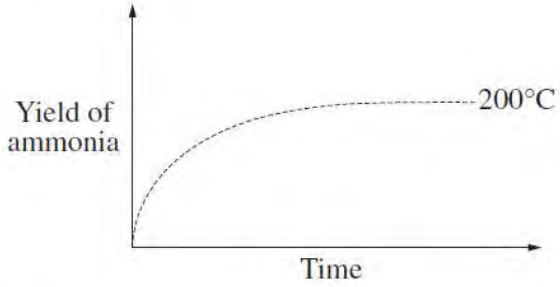
(C) making the water slightly acidic

(D) using a suitable catalyst.

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

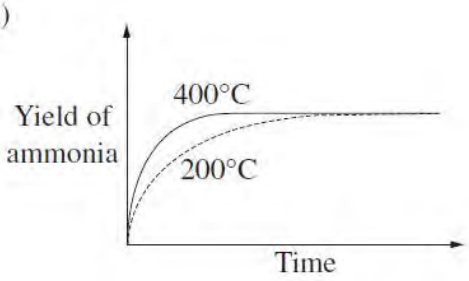
$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The graph shows the yield of ammonia produced at 200°C and 100 kPa.

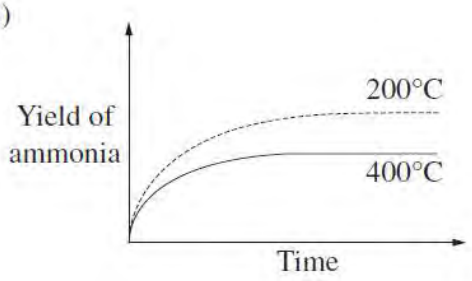


Which graph shows a correct comparison of the yield of ammonia produced at a temperature of 400°C and 100 kPa with the yield produced at 200°C and 100 kPa?

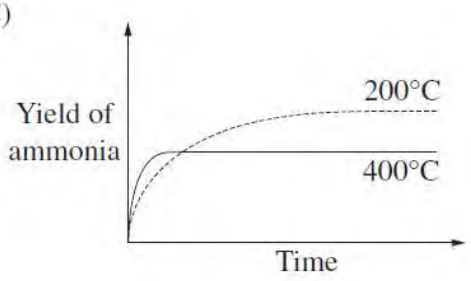
(A)



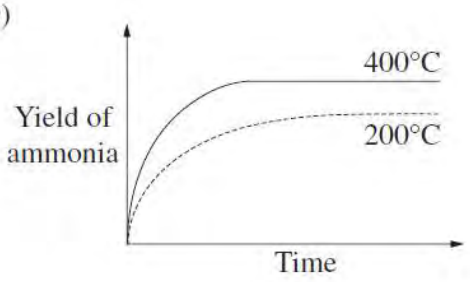
(B)



(C)



(D)



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2010 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Student Number

CHEMISTRY

Part B – 55 marks
Attempt Questions 21- 30
Allow about 1 hour and 40 minutes for this part

Answer the questions in the spaces provided.
Show all relevant working in questions involving calculations.

Question 21 (4 marks) **Marks**

Explain how the structure and properties of polyethylene and polystyrene relate to the way each is used. **4**

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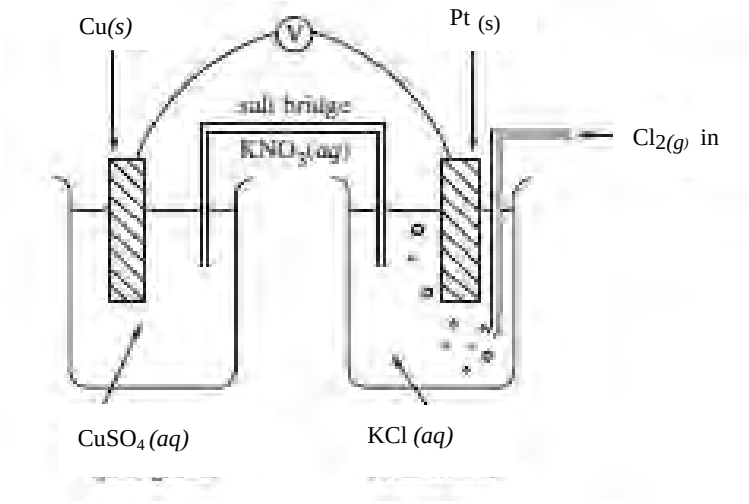
Question 22 (5 marks) **Marks**

A galvanic cell was set up as shown in the diagram below.



(a) On the diagram, label the anode, the cathode and the direction of electron flow. **1**

(b) Write a balanced equation for the overall reaction. **1**

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(c) Assuming the cell is operating under standard conditions, calculate the overall cell potential. **1**

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(d) Other than the cell voltage, explain one observation you would make as the cell was operating. **2**

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Question 23 (5 marks) **Marks**

The table shows properties of some fuels. **5**

Fuel	***Main sources***	***Heat of combustion* (kJ g^{-1})**	***Boiling point* (°C)**
Methane	• Petrochemical industry	55.6	-161.5
Propane	• Petrochemical industry • Natural gas	50.3	-42.1
Octane	• Refined from crude oil	47.9	125.7
Ethanol	• Hydration of ethene • Fermentation	29.7	78.3

Assess the potential of ethanol as an alternative fuel, making use of the data from the table.

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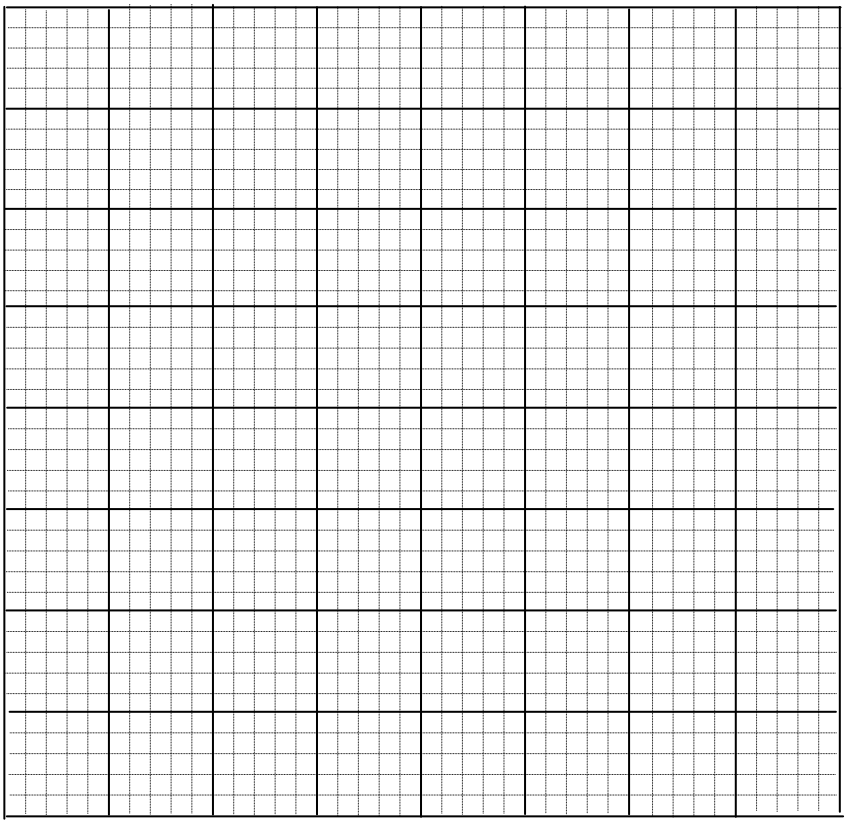
Question 24 (6 marks) **Marks**

The content of lead in red lipsticks is regularly monitored. In one study, the technician was given four standard solutions containing different concentrations of lead ions and asked to measure their absorbance at 400 nm. The results are shown in the table:

Maximum absorbance obtained at 400nm				
Lead Concentration (ppm)	5	15	25	35
Absorbance	0.2	0.6	1.1	1.4

(a) Draw a calibration curve for the above data. **4**



Question 24 (continued) **Marks**

(b) Studies suggest that the average woman consumes 1.8 kilograms of lipstick during her life while consuming food and drinks and licking her lips. The US Food and Drug Administration limits lead in lipstick to 20 parts per million. Assuming all lipsticks comply with this regulation, calculate the maximum mass of lead an average woman would consume over her lifetime. (***Hint:*** Assume all of the lipsticks contain 20 ppm of lead.) **2**

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Question 25 (5 marks)

Scientists have created element 117, named ununseptium (symbol Uus), by firing calcium-48 ions at a berkelium-249 target in a cyclotron.

(a) Assuming no other particles (besides element 117) are produced, write a nuclear equation for this reaction. **1**

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(b) While calcium-48 is a naturally occurring radioisotope, the berkelium-249 target had to be synthesised from uranium-238 in a nuclear reactor. **4**

Compare the production of the berkelium-249 and element 117.

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Question 26 (7 marks) **Marks**

The National Pollutants Inventory revealed that New South Wales' coal-fired power stations produced 5 million kilograms of carbon monoxide and 235 million kilograms of sulfur dioxide in the 2008-2009 year. **7**
Discuss the need to monitor and manage the products of the combustion of coal.

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Question 27 (6 marks) **Marks**

A natural indicator was made by heating yellow flowers with water. The resulting yellow solution was tested with a range of substances. The results are recorded below.

Substance	***Colour***
0.1 M hydrochloric acid	Red
0.1 M ammonia	Yellow
Lemon juice	Orange
Oven cleaner	Yellow
Pure water	Yellow

(a) Assess the usefulness of the yellow solution as an acid-base indicator. **3**

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(b) Describe a procedure that the student could follow to dispose of the used chemicals in a safe manner. **3**

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Question 28 (4 marks) **Marks**

100.0 mL of a solution of 0.250 mol L^{-1} sulfuric acid was added to a solution of 100.0 mL of 0.350 mol L^{-1} potassium hydroxide.

(a) Would the resulting solution be acidic, alkaline or neutral? Explain your answer. **1**

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(b) Calculate the pH of the resulting solution. **2**

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(c) 100.0 mL of distilled water was then added to the solution. Calculate the pH of the diluted solution. **1**

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Question 29 (6 marks) **Marks**

A standard solution was prepared by dissolving 1.314 g of sodium carbonate in water. The solution was made up to a final volume of 250.0 mL.

(a) Calculate the concentration of the sodium carbonate solution. **2**

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The solution was used to determine the concentration of a solution of hydrochloric acid. Five 25.00 mL samples of the acid were titrated with the sodium carbonate solution. The results are shown in the table below.

Sample Number	1	2	3	4	5
Volume of sodium carbonate added (mL)	24.85	23.50	23.35	23.55	23.40

(b) Calculate the concentration of the sodium carbonate solution. **4**

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Question 30 (7 marks) **Marks**

"An industrial chemist carefully considers yield, rate and safety when choosing the reaction conditions to maximise the efficiency of a reaction". **7**

With reference to the above statement, explain the reaction conditions chosen to optimise the Haber process.

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2010 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Chemistry
Section II

25 marks
Answer Question 31
Allow about 45 minutes for this section

Answer the question in a SEPARATE writing booklet.

Show all relevant working in questions involving calculations.

		Page
Question 31	Industrial Chemistry …….....	23

Question 31 – Industrial Chemistry (25 marks) **Marks**

(a) 'The method of extraction of sulfur by the Frasch process is only possible because of the physical properties of the element sulfur.' **4**
Assess this statement.

(b) Sulfuric acid is one of the world's most significant industrial chemicals because of the variety and importance of its uses.

(i) Identify the major use of sulfuric acid. **1**

(ii) Identify a use of sulfuric acid other than that identified in part (i). **1**

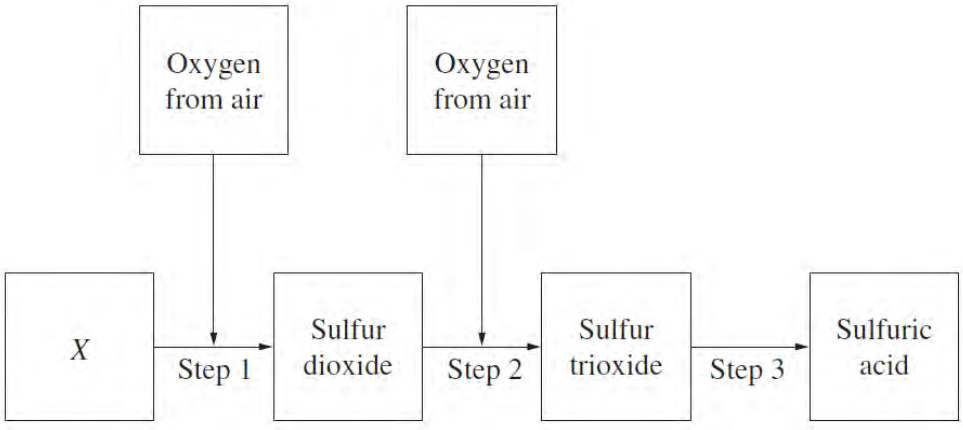
(c) You performed first-hand investigations to observe the reactions of sulfuric acid acting as an oxidising agent and as a dehydrating agent.

(i) Outline a risk assessment for this investigation, and show how this would influence the experimental procedure. **3**

(ii) Justify a conclusion based on one set of observations from your first-hand investigation. **3**

(d) Both mining and the manufacture of chemicals can have environmental costs. **6**
Assess the impact of the Frasch and Contact processes on the environment.

(e) The diagram below summarises the steps in the Contact process.



(i) Identify the starting material, *X*, for the first step in the Contact process. **1**

(ii) Outline the chemistry involved in the conversion of sulfur trioxide to sulfuric acid. **2**

(iii) Justify the conditions you would use to maximise the rate and yield of the second step in the Contact process. Include a balanced chemical equation in your answer. **4**

END OF PAPER

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Student Number

CHEMISTRY – MULTIPLE-CHOICE ANSWER SHEET

ATTEMPT ALL QUESTIONS

Question					
	1	A ●	B ○	C ○	D ○
	2	A ○	B ○	C ○	D ●
	3	A ○	B ●	C ○	D ○
	4	A ●	B ○	C ○	D ○
	5	A ○	B ○	C ○	D ●
	6	A ○	B ○	C ●	D ○
	7	A ○	B ●	C ○	D ○
	8	A ○	B ●	C ○	D ○
	9	A ○	B ○	C ●	D ○
	10	A ○	B ○	C ○	D ●
	11	A ○	B ○	C ○	D ●
	12	A ●	B ○	C ○	D ○
	13	A ○	B ●	C ○	D ○
	14	A ○	B ○	C ○	D ●
	15	A ●	B ○	C ○	D ○
	16	A ○	B ●	C ○	D ○
	17	A ●	B ○	C ○	D ○
	18	A ○	B ○	C ●	D ○
	19	A ○	B ●	C ○	D ○
	20	A ○	B ○	C ●	D ○

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DATA SHEET

Avogadro constant, N_A ..... 6.022×10^{23} mol^{-1}

Volume of 1 mole ideal gas: at 100 kPa and

at 0°C (273.15 K) ..... 22.71 L

at 25°C (298.15 K) ..... 24.79 L

Ionisation constant for water at 25°C (298.15 K), K_w ..... 1.0×10^{-14}

Specific heat capacity of water ..... 4.18×10^3 J kg^{-1} K^{-1}

Some useful formulae

$$\mathrm{pH} = -\log_{10}[\mathrm{H}^+] \qquad \Delta H = -m\,C\,\Delta T$$

Some standard potentials

$K^+ + e^-$	$\rightleftharpoons$	$K(s)$	–2.94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba(s)$	–2.91 V
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	$Ca(s)$	–2.87 V
$Na^+ + e^-$	$\rightleftharpoons$	$Na(s)$	–2.71 V
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	$Mg(s)$	–2.36 V
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al(s)$	–1.68 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn(s)$	–1.18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g) + OH^-$	–0.83 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn(s)$	–0.76 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe(s)$	–0.44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni(s)$	–0.24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn(s)$	–0.14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb(s)$	–0.13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g)$	0.00 V
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(aq) + 2H_2O$	0.16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu(s)$	0.34 V
$\frac{1}{2}O_2(g) + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0.40 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu(s)$	0.52 V
$\frac{1}{2}I_2(s) + e^-$	$\rightleftharpoons$	I^-	0.54 V
$\frac{1}{2}I_2(aq) + e^-$	$\rightleftharpoons$	I^-	0.62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0.77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag(s)$	0.80 V
$\frac{1}{2}Br_2(l) + e^-$	$\rightleftharpoons$	Br^-	1.08 V
$\frac{1}{2}Br_2(aq) + e^-$	$\rightleftharpoons$	Br^-	1.10 V
$\frac{1}{2}O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2}Cl_2(g) + e^-$	$\rightleftharpoons$	Cl^-	1.36 V
$\frac{1}{2}Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2}H_2O$	1.36 V
$\frac{1}{2}Cl_2(aq) + e^-$	$\rightleftharpoons$	Cl^-	1.40 V
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1.51 V
$\frac{1}{2}F_2(g) + e^-$	$\rightleftharpoons$	F^-	2.89 V

Aylward and Findlay, *SI Chemical Data* (5th Edition) is the principal source of data for this examination paper. Some data may have been modified for examination purposes.

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number — 79 — Symbol of element
Atomic Weight — 197.0 — Gold — Name of element

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.41 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [97.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po [209.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223] Francium	88 Ra [226] Radium	89–103 Actinoids	104 Rf [261] Rutherfordium	105 Db [262] Dubnium	106 Sg [266] Seaborgium	107 Bh [264] Bohrium	108 Hs [277] Hassium	109 Mt [268] Meitnerium	110 Ds [271] Darmstadtium	111 Rg [272] Roentgenium							

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [145] Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac [227] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237] Neptunium	94 Pu [244] Plutonium	95 Am [243] Americium	96 Cm [247] Curium	97 Bk [247] Berkelium	98 Cf [251] Californium	99 Es [252] Einsteinium	100 Fm [257] Fermium	101 Md [258] Mendelevium	102 No [259] Nobelium	103 Lr [262] Lawrencium

For elements that have no stable or long-lived nuclides, the mass number of the nuclide with the longest confirmed half-life is listed between square brackets.
The International Union of Pure and Applied Chemistry Periodic Table of the Elements (October 2005 version) is the principal source of data. Some data may have been modified.

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2010 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

CHEMISTRY – MARKING GUIDELINES

Part A – 20 marks
Questions 1-20 (1 mark each)

Question	Correct Response
1	A
2	D
3	B
4	A
5	D
6	C
7	B
8	B
9	C
10	D
11	D
12	A
13	B
14	D
15	A
16	B
17	A
18	C
19	B
20	C

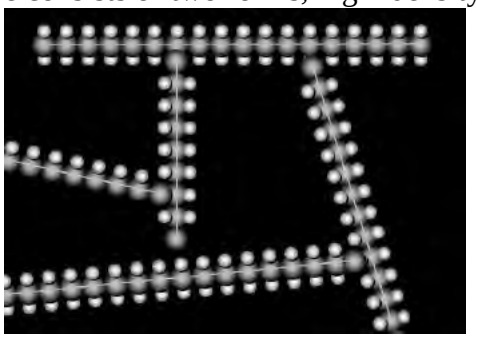
Part B – 55 marks

Question 21 (4 marks)

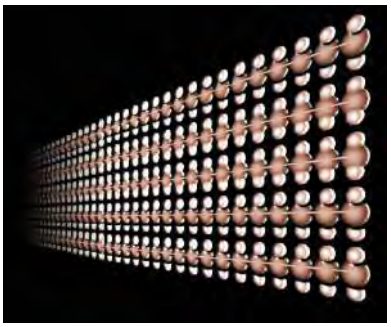
Criteria	Marks
• Explains how the structure and properties of high-density and low-density polyethylene and polystyrene relate to the way each is used.	4
• Identifies a property of either polyethylene and/or polystyrene AND • Identifies a use of either polyethylene and/or polystyrene	2-3
• Identifies a property of either polyethylene or polystyrene OR • Identifies a use of either polyethylene or polystyrene	1

Sample answer

Polyethylene consists of two forms, high–density and low–density.



LDPE



HDPE

HDPE consists of closely packed linear chains with very little branching, resulting in a high proportion of crystalline regions and a strong, hard plastic. These properties make it ideal for use in products where durability is required e.g. plastic buckets and agricultural pipes. LDPE consists of loosely packed chains due to the high degree of branching, resulting in a tough plastic that is soft and flexible. These properties make it ideal for use in products like cling wrap for food and insulation for electrical wires and cables.

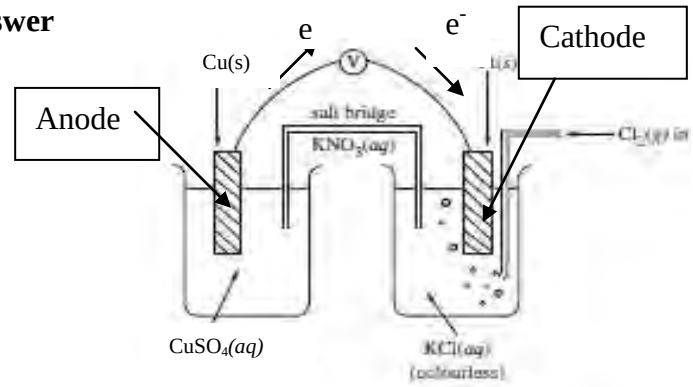
Polystyrene has large benzene rings attached at regular intervals along the length of the polymer chain results in a stiff, clear and rigid plastic. These properties make it suited to its uses in plastic drinking glasses and CD cases.

Better answers put this information into an easily read table.

Question 22 (5 marks)
22 (a) (1 mark)

Criteria	Mark
• Correct answer	1

Sample answer



Common error: NOT labelling correctly the anode and the cathode precisely.

22 (b) (1 mark)

Criteria	Mark
• Writes a balanced equation for the overall equation	1

Sample answer

$Cu\ (s) \rightleftharpoons Cu^{2+}\ (aq) + 2e^-$ $\quad E° = -0.34$ V
$Cl_2\ (g) + 2e^- \rightleftharpoons 2Cl^-\ (aq)$ $\quad E° = +1.36$ V

Overall equation
$Cu\ (s) + Cl_2\ (g) \rightarrow Cu^{2+}\ (aq) + 2Cl^-\ (aq)$

22 (c) (1 mark)

Criteria	Mark
• Correct answer OR • Voltage consistent with half-equations	1

Sample answer

$Cu\ (s) \rightleftharpoons Cu^{2+}\ (aq) + 2e^-$ $\quad E° = -0.34$ V
$Cl_2\ (g) + 2e^- \rightleftharpoons 2Cl^-\ (aq)$ $\quad \underline{E° = +1.36\ V}$
Overall cell potential $\quad = +1.02$ V

Common error: NOT ensuring that correct subscripts or oxidation states used in the ½ equations.

22 (d) (2 marks)

Criteria	Marks
• Explains ONE correct observation	2
• Identifies ONE correct observation	1

Sample answer
The solution in the anode half-cell would become a darker blue as the concentration of copper (II) ions increases due to the oxidation of the copper anode. The hydrated copper ion is responsible for the blue colour. (OR loss of mass of anode due to copper being oxidised).

Question 23 (5 marks)

Criteria	Marks
• Explains the problems and benefits arising from the use of ethanol AND • Makes use of data from the table AND • Provides a judgement of the potential for ethanol to be used as an alternative fuel	4 - 5
• Describes the problems and benefits arising from the use of ethanol AND • Makes use of data in table OR • Provides a judgement of the potential of ethanol as an alternative fuel	2 - 3
• Identifies a property of ethanol that makes it suitable to use as an alternative fuel OR • Identifies one reason for the need for alternative fuels OR • Identifies one aspect of data in table with an advantage or disadvantage of ethanol	1

Sample answer

Should address:

- *Suitability as a fuel (combust) NOT as a fuel additive.(related to heat of combustion)*
- *Suitability for storage and transport (related to Boiling point)*
- *Suitability for continuous production (Related to source)*
- *And comparison made to other fuels listed with hard data included in the response.*

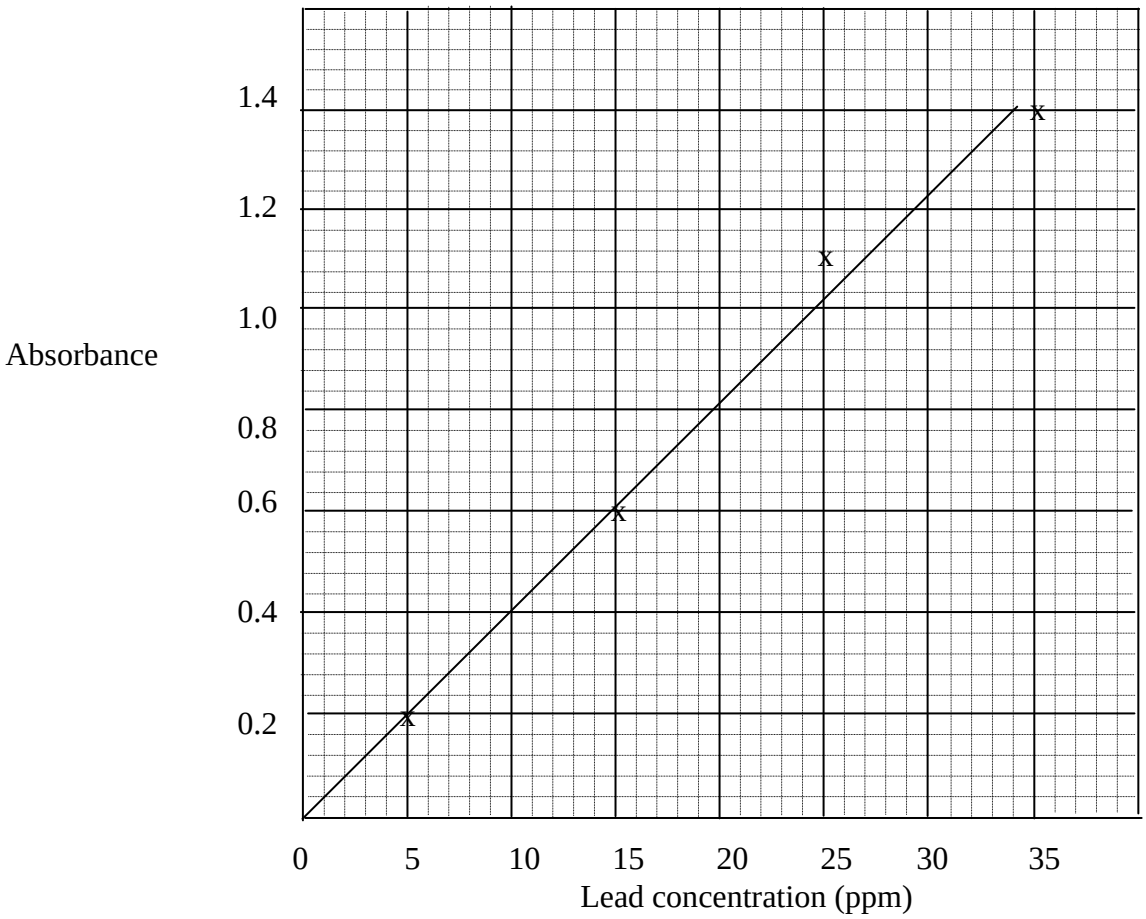
Octane is a liquid at room temperature (boiling point 125.7 °C) and it is pumped through the car from the petrol tank to the engine. Ethanol is also a liquid (boiling point 78.3 °C) and so it suited to be used as a fuel. Methane and propane are both gases (boiling points –161.5 °C and –42.1 °C), so would have to be liquefied before they can be used as a fuel.
Octane releases a lot of energy when it is combusted (47.9 kJ g^{-1}). Methane and propane release a similar amount of energy per gram. Ethanol doesn't release as much heat as octane (29.7 kJ g^{-1}) but it is still sufficient for ethanol to be used as a fuel. Ethanol has the added advantage that it is a renewable fuel although vast amounts of land are needed to grow the crops and a large amount of electricity is required for its distillation, so it can't really be described as "greenhouse neutral".
Ethanol has good potential as an alternative fuel when assessed using boiling point and heat of combustion as criteria.

Common errors:
Clear misunderstanding of what is meant by heat of combustion, the concept that it is more environmentally friendly to burn ethanol, even though more must be burnt to equalize the amount of energy produced.
No assessment made in reference to the data supplied.
Responses "hooked onto" the environmental theme and went into massive description of the fermentation process and the disadvantages of ethanol production which was not required in such detail.
Better answers had this information in a ***table format.***

Question 24 (6 marks)
24 (a) (4 marks)

Criteria	Marks
Correct units and labels X axis	1
Correct units and labels Y axis	1
Correct placements of points on graph	1
Correct drawing of line on graph	1

Sample answer



24 (b) (2 marks)

Criteria	Marks
• Calculates the maximum mass of lead that would be consumed, including units	2
• Calculates the maximum mass of lead that would be consumed but makes a simple error	1

Sample answer

Mass = $1.8 \times 10^3 \times \frac{20}{10^6}$ = 3.6×10^{-2} g

Question 25 (5 marks)
25 (a) (1 mark)

Criteria	Marks
• Writes a correctly balanced equation for the formation of element 117	1

Sample answer

$^{249}_{97}\text{Bk} + {}^{48}_{20}\text{Ca} \rightarrow {}^{297}_{117}\text{Uus}$

25 (b) (4 marks)

Criteria	Marks
• Compares the production of the berkelium-249 and element 117	3 - 4
• Describes the production of the berkelium-249 or element 117	2
• Identifies an aspect of isotope production	1

Sample answer

	berkelium-249	**element 117**
Type of element produced	transuranic	transuranic
Produced in	nuclear reactor	cyclotron
Particle absorbed	neutron	calcium ion
Target particle	Uranium-238	berkelium-249

The main difference is when a positive ion is being fired at the target (e.g. the calcium ion), the ion must be accelerated to very high speeds to overcome the repulsive force between it and the target nucleus and hence a linear accelerator or a cyclotron is used. The absorption of neutrons doesn't require acceleration and as a result can occur in a reactor.

Question 26 (7 marks)

Criteria	Marks
• Describes the negative impacts of carbon monoxide and sulfur dioxide and links them to the need to monitor and manage coal combustion AND • Writes AT LEAST THREE appropriate equations	6 - 7
• Describes the negative impacts of carbon monoxide and sulfur dioxide AND • Identifies a method of managing coal combustion AND • Writes AT LEAST TWO appropriate equations	4 - 5
• Identifies AT LEAST TWO dangers posed by carbon monoxide and sulfur dioxide AND/OR • Writes AT LEAST ONE appropriate equation	2 - 3
• Identifies a danger posed by either carbon monoxide or sulfur dioxide OR • Writes an appropriate equation	1

Sample answer
Answer should include these points or similar ideas

- Carbon monoxide and sulfur dioxide are produced during partial and complete combustion reactions of coal.
- Carbon monoxide is poisonous, causing death by asphyxiation if in large concentrations.
- Sulfur dioxide also causes respiratory problems
- In the atmosphere, sulfur dioxide dissolves in water to form sulphurous acid and can also lead to the formation of sulfuric acid, (acid rain).
- Acid rain affects the pH of soils and water bodies and is detrimental to the metabolism of both plants and animals, which often survive in a specific and narrow pH range.
- The formation of carbon monoxide can be minimised by avoiding incomplete combustion.
- Sulfur dioxide formation can be minimised by using low – sulfur content coals / Sulfur dioxide can be removed from the emissions prior to their release to minimise environmental damage.

And at least 3 equations to illustrate answer -

$2C\,(s) + O_2\,(g) \rightarrow 2CO\,(g)$

$S\,(s) + O_2\,(g) \rightarrow SO_2\,(g)$

$SO_2\,(g) + H_2O\,(l) \rightarrow H_2SO_3\,(aq)$

$2SO_2\,(g) + O_2\,(g) \rightarrow 2SO_3\,(g)$

$SO_3\,(g) + H_2O\,(l) \rightarrow H_2SO_4\,(aq)$

$2H_2SO_3\,(aq) + O_2\,(g) \rightarrow 2H_2SO_4\,(aq)$

And a clear link between the negative impact and the need to monitor e.g.

The dangers posed by these two gases to both individual health and the environment means that it is important to minimise their formation. This can only be achieved by carefully monitoring coal combustion reactions and the products that are formed.

Marker's Comments - Common errors:

- *CO a greenhouse gas*
- *Ignoring management of sulphur dioxide production and often carbon monoxide as well*
- *Insufficient equations to support the answer*
- *Thinking coal was a hydrocarbon*
- *Repeating information from the question*
- *Repeating a rote learnt answer that didn't address the question directly*
- *CO_2 causes acid rain*

Question 27 (6 marks)
27 (a) (3 marks)

Criteria	Marks
• Describes the properties of the indicator over the range of pH values (in acid, neutral and base) • • Provides a judgement	3
• Describes the properties of the indicator over the range of pH values (in acid, neutral and base) but does not provide a judgement OR • Describes the properties of the indicator over range of pH values (in acid, neutral and base solutions) and provides a judgement which is inconsistent with the description, weak or unclear OR • Describes the properties of the indicator for some pH values and provides a consistent judgement	2
• Identifies that an indicator changes colour at different pH values of solutions being tested OR • Identifies that either ammonia or oven cleaner is basic OR • Identifies that lemon juice is a weak acid	1

Sample answer
The indicator is yellow in pure water, which is neutral. However the indicator is also yellow in ammonia and oven cleaner which are basic. The indicator is therefore not useful in distinguishing between neutral and basic solutions.

The indicator is red in strong acid (hydrochloric acid) and orange in the weakly acidic solution (lemon juice). Therefore the indicator is useful in distinguishing acidic from basic and neutral solutions, and also to distinguish strong acids from weak acids.
Marker's Comments - Common errors:
- *Ignoring colour in neutral solution or difference between strong/weak acid*
- *Critical of contrast between red/orange/yellow*
- *Saying indicators can't tell pH*

27 (b) (3 marks)

Criteria	Marks
• Describes how to adjust pH of solution and how to identify that it is safe to dispose of it	2 - 3
• Identifies that solution must be made neutral/basic prior to disposal	1

Sample answer
Mix all the chemicals together in a large beaker and check that the colour of the resulting solution is yellow. If not add a base e.g. bicarbonate of soda until solution turns yellow. When the solution is yellow it is safe to dispose of the mixture down the sink.
Marker's Comments - Common errors:
- *Leaving for collection by teacher/in waste bottle*
- *Neutralising bases, rather than just diluting (if required)*
- *Not using the yellow indicator as an indicator of pH of solutions*
- *Using strong bases for neutralisation*

Question 28 (3 marks)
28 (a) (1 mark)

Criteria	Mark
• Correct explanation	1

Sample answer
No. of moles of sulfuric acid = 0.250 x 0.100 = 0.025 mol
No. of moles of hydronium ions = 2 x 0.0250 = 0.0500 mol

No. of moles of potassium hydroxide = 0.350 x 0.100 = 0.0350 mol
No. of moles of hydroxide ions = 0.0350 mol

Since the no. of moles of hydronium ions is greater (by 0.0150 mol) than the number of moles of hydroxide ion, the solution is acidic.

Marker's Comments - Common errors:
- *Students failed to see acid & base didn't neutralise each other, tried to do it as a pH of salts question*
- *Thinking that KOH was a weak base*

28 (b) (2 marks)

Criteria	Marks
• Calculates the concentration of hydronium ions in the solution AND • Determines the pH of the resulting solution	2
• Calculates the concentration of hydronium ions in the solution	1

Sample answer
An excess of hydronium ions (0.0150 mol) is present in 200 mL of solution.
$[H_3O^+]$ = 0.0750 mol L^{-1}

pH = $-\log_{10} [H_3O^+]$ = $-\log_{10}$ (0.0750) = 1.12 (3 significant figures)

28 (c) (1 mark)

Criteria	Marks
• Determines the pH of the resulting solution	1

Sample answer
Hydronium ions (0.0150 mol) is present in 300 mL of solution.
$[H_3O^+]$ = 0.0500 mol L^{-1}

pH = $-\log_{10} [H_3O^+]$ = $-\log_{10}$ (0.0500) = 1.30 (3 significant figures)

Question 29 (6 marks)
29 (a) (2 marks)

Criteria	Marks
• Calculates the concentration of the sodium carbonate solution, showing ALL steps	2
• Calculates the number of moles of the sodium carbonate solution OR • Calculates the concentration of the sodium carbonate solution using wrong moles or missing working	1

Sample answer

Moles of $Na_2CO_3 = \frac{1.314}{105.99} = 0.01240$ Molar mass of $Na_2CO_3 = 105.99$

Conc. Na_2CO_3 solution $= \frac{\text{moles of } Na_2CO_3}{\text{volume of } Na_2CO_3}$

$= \frac{0.01240}{0.0250}$

$= \underline{0.04959}$

Marker's Comments - Common errors:

- $NaCO_3$ – *incorrect formula for* Na_2CO_3
- $n = \frac{c}{v}$ *used instead of* $c = \frac{n}{v}$

29 (b) (4 marks)

Criteria	Marks
• Calculates concentration for HCl correctly to 4 significant figures	4
• Calculates concentration of HCl correctly but incorrect significant figures OR • Calculates concentration of HCl correctly without using mole ratio OR • Calculates concentration of HCl with minor error in the last step to 4 significant figures	3
• Calculates moles of Na_2CO_3 correctly OR • Uses correct ratio of 2 : 1 for HC1 : Na_2CO_3	2
• Calculates average titre correctly OR/AND • Writes correctly balanced equation	1

Sample answer:

$$Na_2CO_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$$

Average volume for titration = $\frac{23.50 + 23.35 + 23.55 + 23.40}{4}$

= 23.45 mL

Moles of Na_2CO_3 used for the titration = c x v

= 0.04959 x .02345

= 0.001163

Moles of HCl needed to neutralise Na_2CO_3 = 2 x moles of Na_2CO_3 used

= 2 x 0.001163

= 0.002326

Conc. HCl solution = $\frac{\text{moles of HCl}}{0.0250}$

= $\frac{0.002326}{0.0250}$

= 0.09303 mol L^{-1} (4 significant figures)

Marker's Comments - Common errors:

- *Significant figures!!*
- *Using the dilution equation, instead of setting out answer showing all working.*

Q**uestion 30** (7 marks)

Criteria	Marks
• Thorough explanation of the impact of the factors: temperature, pressure, use of a catalyst, the concentrations of reactants and product and safety on the optimum conditions for production of ammonia AND • Includes a balanced equilibrium equation for the synthesis	6-7
• Sound analysis of the impact of the factors: temperature, pressure, use of a catalyst, the concentrations of reactants and product, safety and costs - on the optimum conditions for production of ammonia, including a balanced chemical equation OR • Thorough analysis of the impact ON SAFETY, RATE AND YIELD of SOME of the factors: temperature, pressure, use of a catalyst, the concentrations of reactants and product***, safety*** and costs - on the optimum conditions for production of ammonia, including a balanced chemical equation	4-5
• Sound analysis of the impact of SOME of the factors: temperature, pressure, use of a catalyst, the concentrations of reactants and product, safety and costs - on the optimum conditions for production of ammonia	2-3
• Identifies a reaction condition used in the Haber process OR • Writes a balanced equilibrium equation for the synthesis OR • Identifies a factor to consider when choosing reaction conditions	1

Sample answer

Answers should address how the following factors impact safety, yield and rate.

- Temperature
- Pressure
- Catalyst
- Stoichiometry

Some points that could be included are

REACTION CONDITION	SAFETY	YIELD	RATE
Temperature a compromise between rate and yield is reached at 400°C	Lower temp. conditions preferred	Exothermic reaction, increased yield at lower temperature	Increases with temp.
Pressure 250 atms is commonly used	High pressures pose serious risks	Increased pressure increases yield	Increases with pressure
Catalyst Fe_3O_4	Allows chosen temp. to be lower, thereby indirectly influencing safety	Allows chosen temp. to be lower, thereby indirectly influencing yield	Increases the rate for a given temperature
Stoichiometry $N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g)$	Impurities e.g. oxygen can compromise safety	Equilibrium reaction, yield increased by removal of ammonia	Optimum rate requires 1:3 ratio of reactants

Question 31 (25 marks)
31 (a) (4 marks)

Criteria	Marks
• Assesses the statement with reference to the Frasch process and sulfur's physical properties	4
• Discusses the statement with reference to the Frasch process and sulfur's physical properties	2 - 3
• Identifies a physical property of sulfur	1

Sample answer
The Frasch process relies on the physical properties of sulfur for its success. Sulfur's low melting point (<120°C) means that it is easily melted by superheated steam at 150 °C. The low density of sulfur (2.07 g cm^{-3}) means that the sulfur-water emulsion is easily transported to the surface using compressed air. Sulfur's lack of solubility in water and the fact that it doesn't react with water allow sulfur to be easily separated from water when the mixture cools. Thus, the statement is accurate when it says, "the Frasch process is only possible because of the physical properties of the element sulfur."

31 (b) (i) (1 mark)

Criteria	Marks
• Identifies the major use of sulfuric acid	1

Sample answer
Fertiliser production

31 (b) (ii) (1 mark)

Criteria	Marks
• Identifies another use of sulfuric acid	1

Sample answer
Paint manufacturing

31 (c) (i) (3 marks)

Criteria	Marks
• Outlines TWO specific hazards for this first-hand investigation, AND provides a specific method for control of each hazard, including that only a teacher should conduct the experiment and that a fume cupboard should be used	3
• Outlines ONE specific hazard for this first-hand investigation, AND provides a method for its control, including that only a teacher should conduct the experiment OR that a fume cupboard should be used OR • Outlines TWO specific hazards for this first-hand investigation	2
• Provides ONE method of controlling a specific hazard for this first-hand investigation OR • Identifies ONE specific hazard for this first-hand investigation	1

Sample answer
The chemicals being used (sulfuric acid and hexane) contain noxious vapours and so experiment should be conducted in a fume cupboard, this would also help to ventilate the halogen vapors produced. Concentrated sulfuric acid is highly corrosive, so only a teacher should conduct the experiment. The teacher should be wearing safety glasses, gloves and a laboratory coat.

31 (c) (ii) (3 marks)

Criteria	Marks
• States a conclusion AND • Describes observations that clearly support the conclusion stated	3
• States a conclusion AND • Identifies an observation that would be made during the experiment OR • Describes observations that would be made during the experiment	2
• States a conclusion OR • Identifies an observation that would be made	1

Sample answer
Observations: When a few mL of concentrated sulfuric acid is added to sugar, the sugar turned golden brown, then a darker brown and finally a black solid mass which expanded and rose up the beaker. The black solid mass was the carbon that was left behind once water was removed from the sugar.
Conclusion: Concentrated sulfuric acid can act as a dehydrating agent.

31 (d) (6 marks)

Criteria	Marks
• Assesses the impact of BOTH the Frasch and Contact processes on the environment. AND • Describes the impact of the Frasch and Contact processes on the environment, providing extensive examples for both processes.	6
• Assesses the impact of EITHER the Frasch and Contact processes on the environment. AND • Describes the impact of the Frasch and Contact processes on the environment, providing several examples.	4-5
• Describes the impact of EITHER the Frasch and Contact processes on the environment, providing several examples and attempts an assessment of the impact. OR • Describes the impact of the Frasch and Contact processes on the environment, providing at least TWO examples.	2-3
• Identifies an environmental impact of one of the processes	1

Sample answer

Some examples that could have been included in answers are:

For the Frasch process

- The underground caverns that remain after mining are difficult to back-fill and can result in land subsidence.
- The water needs to be recycled, as it may have dissolved impurities that would contaminate the environment if released.
- The potential environmental problem of thermal pollution.
- There is potential for the heated sulfur to react with oxygen to form sulfur dioxide gas or to be reduced to form hydrogen sulfide gas
- If fossil fuels are burnt to supply the heat for the steam, carbon dioxide gas will be made, which is a greenhouse gas
- If fossil fuels are burnt to supply the heat for the steam nitrogen and sulfur oxides may form, which can result in acid rain.

For the Contact process

- Sulfur dioxide and sulfur trioxide can be released into the environment, resulting in acid rain.
- Extra catalyst beds and absorption towers results in minimal sulfur dioxide being released during the process.
- Due to the reactions in the process being exothermic, the amount of energy needed for the process is greatly reduced, minimising the environmental impacts associated with burning fossil fuels.
- If sulfur dioxide from smelting sulfide ores is used as the starting material for the process, this reduces the potential environmental damage that would result from the sulfur dioxide being released into the environment.

Assessment

Each process should be assessed independently i.e. a clear statement for the impact of each.

31 (e) (i) (1 mark)

Criteria	Marks
• Identifies the starting material	1

Sample answer
Sulfur

31 (e) (ii) (2 marks)

Criteria	Marks
• Outline the chemistry involved in the conversion of sulfur trioxide to sulfuric acid AND • Includes **TWO** equations to illustrate the process	2
• Provides ONE appropriate balanced chemical equation OR • Identifies that oleum is formed as an intermediate OR • Identifies ONE of the steps involved in the conversion	1

Sample answer
Sulfur trioxide is reacted with sulfuric acid to produce oleum.

$$SO_3(g) + H_2SO_4(l) \rightarrow H_2S_2O_7(l)$$

This is done because dissolving SO_3 directly in water to produce H_2SO_4 is very exothermic and results in the formation of a sulfuric acid mist which is dangerous and difficult to handle.

Water can then be mixed with the oleum (under safer conditions) and 98% pure (18M) sulfuric acid is produced.

$$H_2S_2O_7(l) + H_2O(l) \rightarrow H_2SO_4(l)$$

31 (e) (4 marks)

Criteria	Marks
• Uses Le Chatelier's principle to justify one set of reaction conditions that will maximise the yield of SO_3 • Writes a balanced chemical equation • Justifies the need to use an intermediate reaction temperature to maximise yield because of the exothermic nature of the reaction • Identifies that a catalyst should be used to maximise reaction rate	3-4
• Justifies a condition that could be used to maximise the rate OR the yield of the second step in the Contact process AND • Includes a balanced chemical equation in the answer.	2
• Identifies a condition that could be used to maximise the rate OR the yield of the second step in the Contact process OR • Includes a balanced chemical equation in the answer.	1

Sample answer

The second step in the Contact process is the conversion of $SO_2(g)$ into $SO_3(g)$. It is an equilibrium reaction and is exothermic.

$$SO_2(g) + \tfrac{1}{2}O_2(g) \rightleftharpoons SO_3(g) + \text{heat}$$

According to Le Chatelier's principle the conditions required to maximise the yield of $SO_3(g)$ are:

- Low temperature (because the forward reaction is exothermic)
- High pressure (because the forward reaction produces fewer moles of gas)
- An excess of oxygen (excess reactant favours the formation of the product)

Rate of reaction also needs to be considered. A higher reaction can be achieved by increasing the temperature and pressure and by using a catalyst.

There is a conflict between the optimal temperature to maximise yield and the temperature required to maximise rate (since the reaction is exothermic). As a result I would choose a compromise temperature of about 600°C, to achieve a practical compromise between rate and yield.

A high yield is achievable at atmospheric pressure, so it is safer and more cost effective to conduct this step of the Contact process at atmospheric pressure.

A ratio of 2 moles of $O_2(g)$ to 1 mole of $SO_3(g)$ will increase the yield and is cost effective as oxygen is cheap and easy to obtain.

$V_2O_5(s)$ would be used as a catalyst to increase the rate of reaction by lowering the activation energy. This would also enable the reaction to proceed at a lower temperature, thereby increasing the overall yield of $SO_3(g)$.