



ABBOTSLEIGH

Student number \_\_\_\_\_

**AUGUST 2010**

**HIGHER SCHOOL CERTIFICATE  
ASSESSMENT**

# Chemistry

## 2 Unit

### General Instructions

- Time allowed – **3 hours**.
- This paper contains **TWO** sections covering Core and Options.
- Write using black or blue pen.
- Draw diagrams using pencil.
- Board-approved calculators may be used.
- A Periodic table and data sheet is provided.

### SECTION I

Total marks – 75

#### The Core

- Attempt all questions.
- **Part A** - 20 multiple choice questions (1 mark each)
- Answer on the grid provided
- **Part B – Questions 21-31**
- Free response questions.
- Answer in the spaces provided.
- Show all working.

### SECTION II

**The Option –total marks 25**

Answer the questions on Industrial Chemistry in the booklet provided.

**SECTION I**  
**PART A**  
**MULTIPLE CHOICE**

**Questions 1-20**

**1 mark each**

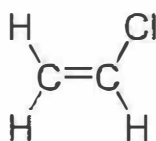
**Attempt Questions 1-20 on the multiple choice answer sheet.**

**Allow about 35 minutes for this part.**

1. Which of the following isotopes undergoes alpha decay to form thorium-234?

- (A) Actinium-234
- (B) Actinium-238
- (C) Uranium-238
- (D) Plutonium-236

2. Which of the following correctly identifies this monomer?



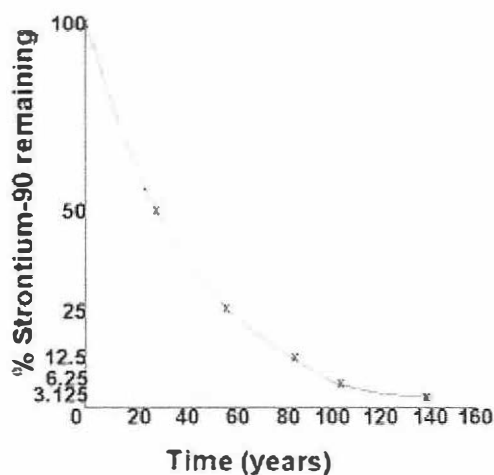
	<i>Systematic name</i>	<i>Preferred Name</i>
(A)	Styrene	Chloroethene
(B)	Chloroethene	Vinyl chloride
(C)	Vinyl chloride	Chloroethene
(D)	Chloroethene	Styrene

3. A chemist observed a colour change after adding bromine water,  $\text{Br}_{2(aq)}$ , to an unknown hydrocarbon.

Which one of the following substances could she have produced in this reaction?

- (A) pentane
- (B) 2-pentene
- (C) 2,3-dibromopentane
- (D) 1,3-dibromopentane

4. The graph shows the radioactive decay of strontium-90.



The half-life of this isotope is approximately

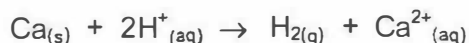
- (A) 30 years
- (B) 40 years
- (C) 50 years
- (D) 100 years

5. The heat released when ethanol ( $C_2H_5OH$ ) was burnt in air was used to heat an aluminium can containing 500.0 g of water. When the temperature of the water had increased by  $20.0^\circ C$  the mass of the spirit lamp had decreased by 1.30 g.

Using this information, the enthalpy of combustion of ethanol can be determined to be

- (A)  $-32\,200\text{ J mol}^{-1}$
- (B)  $-41\,800\text{ J mol}^{-1}$
- (C)  $-5\,400\text{ J mol}^{-1}$
- (D)  $-1\,480\,000\text{ J mol}^{-1}$

6. Consider the following reaction involving hydrogen ions:



Which statement about the hydrogen ions in this reaction is CORRECT?

- (A) They are classified as the oxidising agent.
- (B) They undergo an increase in oxidation state.
- (C) They lose electrons.
- (D) They undergo an acid-base reaction with calcium metal.

7. A  $4 \text{ mol L}^{-1}$  solution of an acid HX was found to have a pH of 4.6. This solution would best be described as a

- (A) concentrated solution of a weak acid.
- (B) concentrated solution of a strong acid.
- (C) dilute solution of a weak acid.
- (D) dilute solution of a strong acid.

8. Which action would result in a decrease of THREE pH units of the solution?

- (A) Diluting 10.0 mL of  $0.01 \text{ mol L}^{-1}$  HCl (aq) to 80.0 mL
- (B) Diluting 10.0 mL of  $0.01 \text{ mol L}^{-1}$  NaOH (aq) to 80.0 mL
- (C) Diluting 10.0 mL of  $0.01 \text{ mol L}^{-1}$  HCl (aq) to 10000.0 mL
- (D) Diluting 10.0 mL of  $0.01 \text{ mol L}^{-1}$  NaOH (aq) to 10000.0 mL

9. The most accurate and appropriate procedure for determining the concentration of a solution of sodium hydroxide by titration would be to titrate it against a solution of

- (A) hydrochloric acid, which had been made up as a primary standard.
- (B) hydrochloric acid, which had been previously standardised against the primary standard, sodium carbonate.
- (C) the primary standard, sodium carbonate.
- (D) diluted vinegar solution.

10. A student mixed 40 mL of  $0.04 \text{ mol L}^{-1}$  HCl with 10 mL of  $0.15 \text{ mol L}^{-1}$  NaOH. What is the pH of the resulting solution?

- (A) 1.1
- (B) 2.7
- (C) 4.0
- (D) 7.0

11. Which of the following is NOT a conjugate acid/base pair?

- (A)  $\text{H}^+/\text{OH}^-$
- (B)  $\text{HCl}/\text{Cl}^-$
- (C)  $\text{NH}_3/\text{NH}_2^-$
- (D)  $\text{H}_2\text{CO}_3/\text{HCO}_3^-$

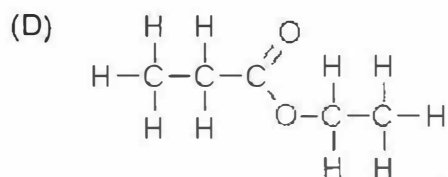
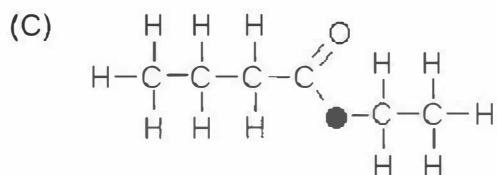
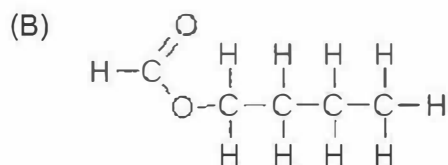
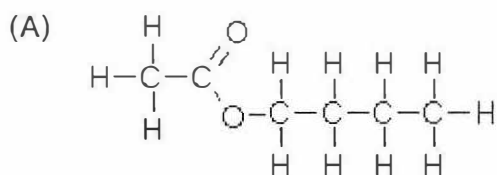
12. This question refers to the following substances:

- i.  $\text{H}_2\text{CO}_3$
- ii.  $\text{NH}_4\text{Cl}$
- iii.  $\text{NaCH}_3\text{COO}$
- iv.  $\text{CH}_3\text{COOH}$

Solutions of which of the substances listed would turn blue litmus red?

- (A) (i) only
- (B) (i) and (iv)
- (C) (i), (ii) and (iv)
- (D) (i), (iii) and (iv)

13. The organic compound formed from the reaction of ethanol and butanoic acid, in the presence of concentrated sulfuric acid, is best represented as



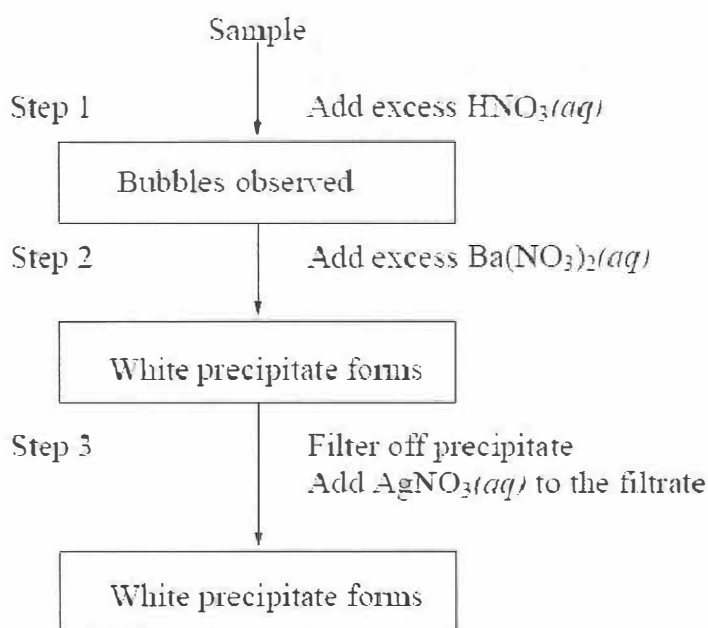
14. Identify the correct statement comparing a chlorine free radical and a chlorine atom.

- (A) There is no difference in the electron arrangement of the free radical and the atom.
- (B) The free radical has fewer electrons than the atom.
- (C) The free radical has more electrons than the atom.
- (D) The free radical has unpaired electrons, whereas the atom does not.

15. Which of the following best explains why the increase in the size of the hole in the ozone layer, observed in past decades, was considered a problem for humans and for the environment?

- (A) The hole allowed more ozone from the stratosphere to pollute the troposphere.
- (B) The hole allowed the CFCs released into the troposphere to reach the stratosphere.
- (C) The hole allowed more high energy UV radiation to reach the Earth's surface.
- (D) The hole indicated that too much oxygen was being converted into ozone by the effect of UV radiation.

16. The flow diagram below shows 3 steps that can be used to identify carbonate, chloride and sulfate ions present in a sample.



The products formed in the THREE steps, in order, are

- (A) carbon dioxide gas, barium sulfate, silver chloride.
- (B) hydrogen gas, barium chloride, silver sulfate.
- (C) hydrogen gas, barium sulfate, silver chloride.
- (D) carbon dioxide gas, barium chloride, silver sulfate.

17. The hardness of water can be reduced by decreasing the concentration of ions causing hardness. This is best achieved by

- (A) adding iron (III) salts, to bring about flocculation of the ions.
- (B) using membrane filters, to remove the ions.
- (C) allowing the water to stand, to cause sedimentation of the ions.
- (D) adding sodium carbonate, to precipitate the ions.

18. A chemistry class was asked to determine the % of sulfate in lawn fertiliser. According to the packet, the fertiliser contained 36% sulfate by mass.

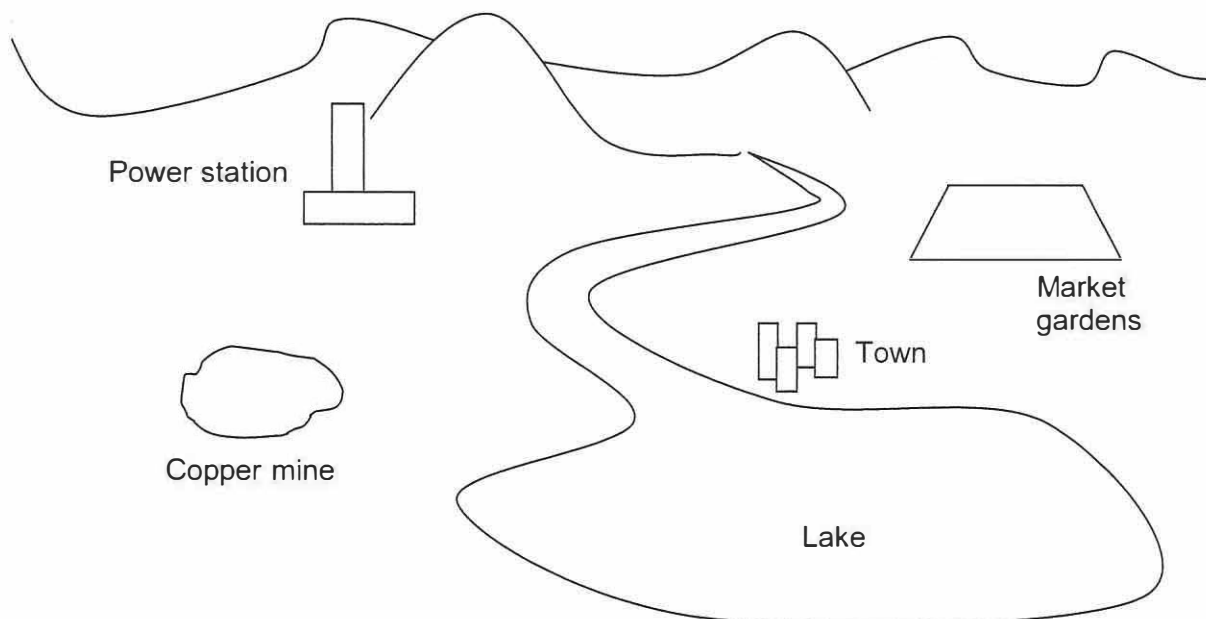
Each student weighed out 2.00 g of the lawn fertilizer and dissolved it in dilute nitric acid. They added excess 2M barium nitrate solution and noted that a white precipitate formed. They then followed slightly different techniques to obtain dry samples of barium sulfate, which they weighed carefully. Each student repeated the investigation 3 times. Their results are shown below.

Student	Mass of ppt (g)			
	TRIAL 1	TRIAL 2	TRIAL 3	Average
1	1.12	1.56	1.30	1.33
2	1.87	1.80	1.72	1.80
3	1.75	2.15	1.46	1.79
4	1.35	1.40	1.45	1.40

Which student's results could be described as being the most accurate and reliable?

- (A) Student 1
- (B) Student 2
- (C) Student 3
- (D) Student 4

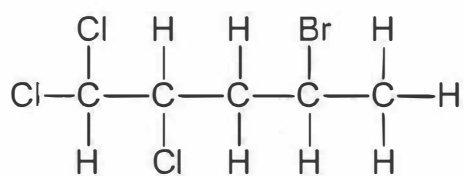
19. The lake indicated in the diagram below is showing signs of eutrophication.



Which is the most likely source of contaminants that would result in this problem?

- (A) Copper mine
- (B) Power station
- (C) Town
- (D) Market garden

20. What is the correct systematic name for the compound having the structure below?



- (A) 4-bromo-1,1,2-trichloropentane
- (B) 4,5,5-trichloro-2-bromopentane
- (C) 2-bromo-4,5,5-trichloropentane
- (D) 1,1,2-trichloro-4-bromopentane



## PART B

Attempt Questions 21-32

Allow about 1 hour and 40 minutes for this part.

Answer the questions in the spaces provided.

Show all working.

Marks

### QUESTION 21 (5 marks)

Most modern cars run on unleaded petrol. One common component of petrol is 3,4-dimethyl-1-pentene.

(a) (i) Draw a structural formula for 3,4-dimethyl-1-pentene. 1

(ii) Determine the molecular formula of this molecule. 1

---

(b) The chemical energy in the petrol is partly released when it undergoes combustion. Write a balanced molecular equation for the complete combustion of the above petrol component. 1

---

(c) Considerable research is currently being undertaken around the world to find liquid fuel alternatives to petrol. Ethanol is one alternative. Explain why ethanol fuel reduces toxic emissions to the environment. 2

---

---

---

---

**QUESTION 22 (5 marks)**

A galvanic cell was constructed using copper, silver, and appropriate solutions of their salts.

- (a) Write redox half reactions for the reaction that occurs in this cell and calculate the cell voltage.

2

---

---

---

- (b) Draw a galvanic cell using one of the redox couples from the answer to (a), but which would produce a greater voltage than you calculated in (a).

3

**QUESTION 23 (4 marks)**

7.50 g of a pure, monoprotic alkanolic acid (represented as HX) is reacted with excess  $\text{Na}_2\text{CO}_3$  producing 2.02 L of dry carbon dioxide gas, measured at 25°C and 100 kPa pressure.

- (a) Calculate the moles of carbon dioxide gas released by this reaction. 1

---

---

- (b) Use your answer to (a) to calculate the molar mass of the alkanolic acid. 2

---

---

---

---

- (c) Draw the structural formula of the alkanolic acid. 1

---



**QUESTION 25 (7 marks)**

In May 2009, an estimated 4000 Brisbane homes were supplied with water with unacceptably high levels of the fluoride ion. The water they were supplied with contained up to 31 mg/L of fluoride instead of the maximum allowable 1.5 mg/L. The high fluoride levels were due to an error made at a water treatment plant, which was not detected until after the release of the water. Fluoride poisoning may result in a number of adverse health effects, including extreme nausea.

- (a) Given that high levels of fluoride can result in adverse health effects, account for addition of fluoride to the mass water supply. 1

---



---

- (b) Calculate the moles of fluoride ion present in a 250 mL glass of water containing the maximum acceptable levels of fluoride. 2

---



---



---

- (c) Accidents such as the one described above illustrate the need for careful monitoring of the quality of the mass water supply. Describe TWO other tests which must be carried out on water prior to its release for public consumption and justify the need for each test. 4

---



---



---



---



---



---



---



---



---



---

**QUESTION 26 (4 marks)**

The dihydrogen phosphate ion  $\text{H}_2\text{PO}_4^-$  is amphoteric, yet an aqueous solution of  $\text{KH}_2\text{PO}_4$  has a pH greater than 7.

- (a) Explain, using appropriate equations, why the dihydrogen phosphate ion is classified as amphoteric.

2

---

---

---

---

---

---

---

---

---

---

- (b) Explain, using an appropriate equation, why an aqueous solution of potassium dihydrogen phosphate has a pH greater than 7.

2

---

---

---

---

---

---

---

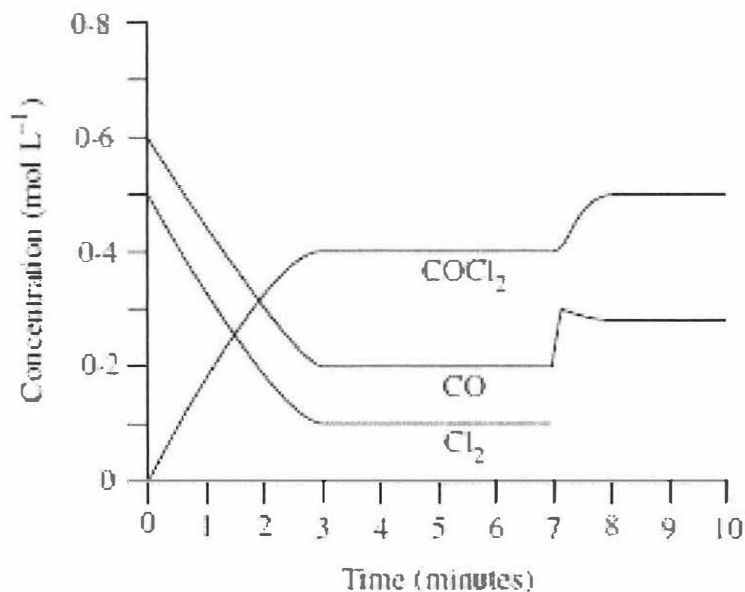
---

**QUESTION 27 (5 marks)**

Phosgene,  $\text{COCl}_{2(g)}$ , is produced from chlorine and carbon monoxide according to the equation:



When chlorine and carbon monoxide are mixed in the presence of activated charcoal, the concentrations of each gas change as shown on the graph below.



- (a) Explain qualitatively the changes in the curves shown on the graph over the 10 minute period.

3

---

---

---

---

---

---

---

---

---

---

---

---





### QUESTION 29 (6 marks)

Scientists use atomic absorption spectroscopy (AAS) for many different analyses.

A group of scientists used AAS to investigate the trace elements in THREE commercially available vitamin tablets. In one investigation, they used AAS to determine the concentration of zinc ions ( $\text{Zn}^{2+}$ ) in solutions they made by dissolving each of the three tablets separately in the same volume of deionised water.

They used samples of known concentration of zinc ions to calibrate their instrument and then tested the three different brands of vitamin tablets.

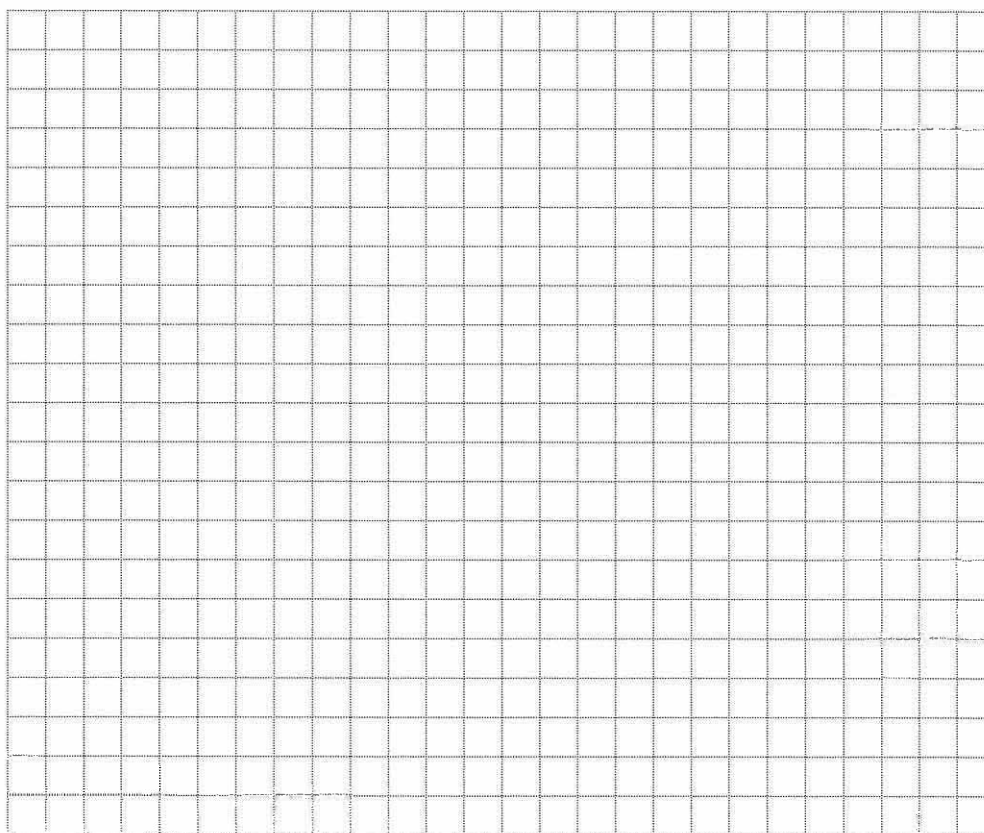
The absorbances of the standards are given below:

Standards [ $\text{Zn}^{2+}$ ] (ppm)	1	2	4	6	10	12
Absorbance	0.10	0.17	0.34	0.49	0.84	0.99

- (a) Draw a calibration curve of the absorbance versus concentration (ppm) for the standards on the grid below.

2

Absorbance



Concentration  $\text{Zn}^{2+}$  (ppm)

**Marks**  
1

- (b) The absorbances of solutions made from the THREE different brands of vitamin tablets are given below.

Brand	A	B	C
Absorbance	0.26	0.86	0.56

Use the calibration curve from part (a) to determine the concentration of zinc ions in the vitamin tablet with the highest concentration of zinc ions. Indicate on the calibration curve how you obtained this answer.

---

- (c) Scientists also use AAS to monitor and manage the environment.

3

Discuss the use of AAS in pollution control.

---

---

---

---

---

---

---

---

---

---

---

**QUESTION 30 (5 marks)**

Over 1 million kilograms of methyl methanoate is used as an industrial solvent or pharmaceutical intermediate each year. Methyl methanoate is an excellent industrial solvent; its boiling point is lower, and it is less soluble in water, than either methanol or methanoic acid. Methyl methanoate can be prepared by the following procedure.

Methanol (0.31 mol), methanoic acid (0.10 mol) and 1 drop of concentrated sulfuric acid were heated under reflux for 30 minutes. The mixture was then distilled to give pure methyl methanoate as a colourless liquid boiling at 33°C (0.080 mol).

- (a) Demonstrate, using structural formulae, why the boiling points of methyl methanoate and methanoic acid differ.

3

---

---

---

---

---

---

---

- (b) Justify the decision, in this preparation of methyl methanoate, to 'heat under reflux'.

2

---

---

---

---

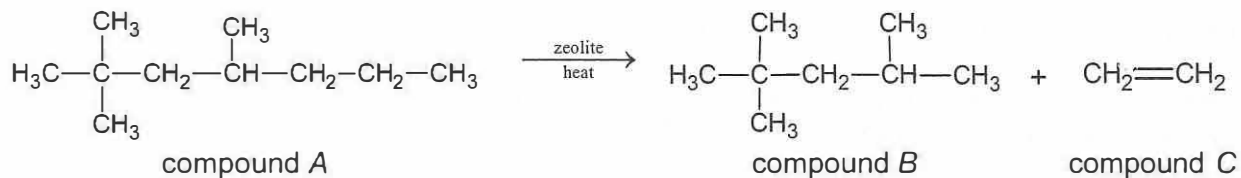
---

---

---

## QUESTION 31 (5 marks)

An important chemical process involved in the preparation of industrial chemicals from crude oil can be represented by the following chemical equation:



- (a) Name a chemical process that involves this type of chemical reaction. 1

---

- (b) Using IUPAC nomenclature, name compound A. 1

---

- (c) Compare the reactivity of compound B with the reactivity of compound C when each compound is treated with solutions of sulfuric acid dissolved in water. 3

---



---



---



---



---



---



---



---

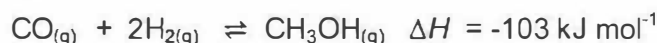
**SECTION II**  
**OPTION: INDUSTRIAL CHEMISTRY**

Answer all questions in the booklet provided.  
Allow about 45 minutes for this section.

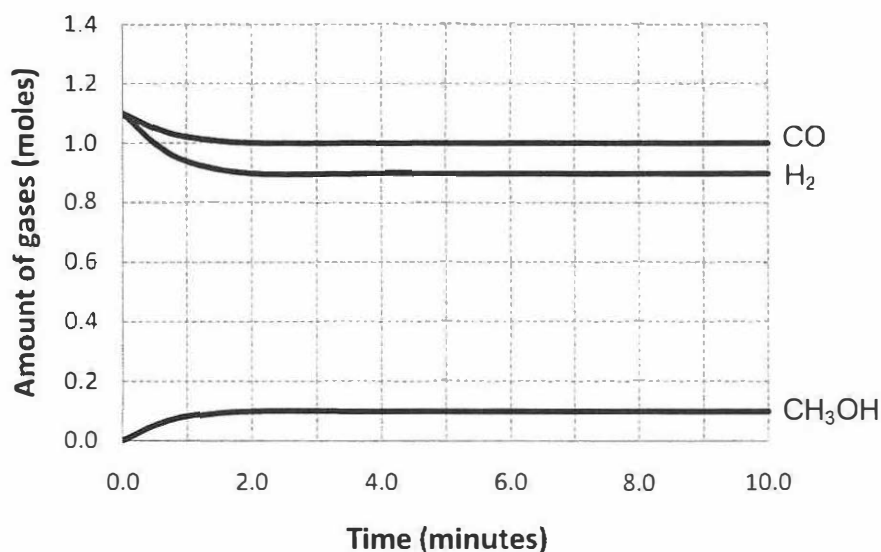
**QUESTION 32 — Industrial Chemistry (25 marks)**

**Marks**

- (a) Sulfuric acid is an extremely important industrial chemical.
- (i) Describe TWO different types of chemical reactions involving sulfuric acid. Include equations for each type of chemical reaction you describe. 4
- (ii) During your practical work you performed a first-hand investigation to observe reactions of sulfuric acid. Choose ONE of the reactions observed and describe the procedure you used and the results you obtained 2
- (iii) Outline how you minimised TWO identified risks associated with your procedure in (ii). 2
- (iv) Explain why Le Chatelier's principle must be considered in controlling the industrial production of sulfur trioxide from sulfur dioxide. 2
- (b) Methanol can be produced by the reaction of the gases carbon monoxide and hydrogen according to the equation:



The graph shows the results of an experiment when  $\text{CO}_{(g)}$  and  $\text{H}_{2(g)}$  were added to a 10 L vessel at a temperature of  $500^\circ\text{C}$ .



- (i) Write an expression for the equilibrium constant. 1
- (ii) Calculate the value of the equilibrium constant for the reaction under the above conditions. 2
- (iii) If the experiment were carried out at a temperature of  $250^\circ\text{C}$ , what effect would this have on the equilibrium constant? Explain your reasoning. 2

**Question 32 continues on the next page**

	<b>Marks</b>
(c) An important role of chemistry is to provide for our material needs, in an environmentally and socially viable way.	
(i) Identify a shrinking natural resource (which is not a fossil fuel).	1
(ii) Outline issues associated with the reduction in the availability of this resource, and identify a current or potential solution.	2
(d) Consider the following equation for the industrially important 'water-gas shift reaction':	2
$\text{CO}_{(g)} + \text{H}_2\text{O}_{(g)} \rightleftharpoons \text{H}_{2(g)} + \text{CO}_{2(g)} \quad \Delta H = -42 \text{ kJ mol}^{-1}$	
The equilibrium constant for this reaction, at 1260 K, is 0.62. Analysis of a reaction mixture at 1260 K revealed that $[\text{H}_2] = 0.35\text{M}$ , $[\text{CO}_2] = 0.25\text{M}$ , $[\text{H}_2\text{O}] = 0.55\text{M}$ and $[\text{CO}] = 0.55\text{M}$ . Explain whether the system was at equilibrium at the time these measurements were taken.	
(e) (i) Identify ONE property of sulfur that allows it to be extracted from underground mineral deposits.	1
(ii) Describe the processes involved in the extraction of sulfur from underground mineral deposits.	2
(f) Identify the raw materials used in the Solvay Process.	2

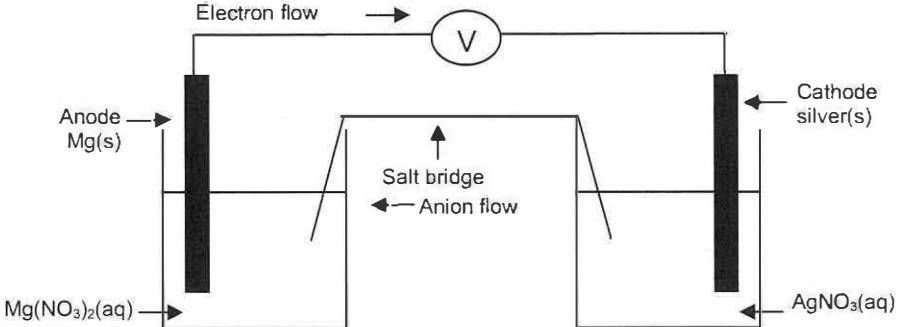
**END OF PAPER**

**HSC CHEMISTRY**  
**August 2010 Trial**  
**Core Marking Scheme**

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

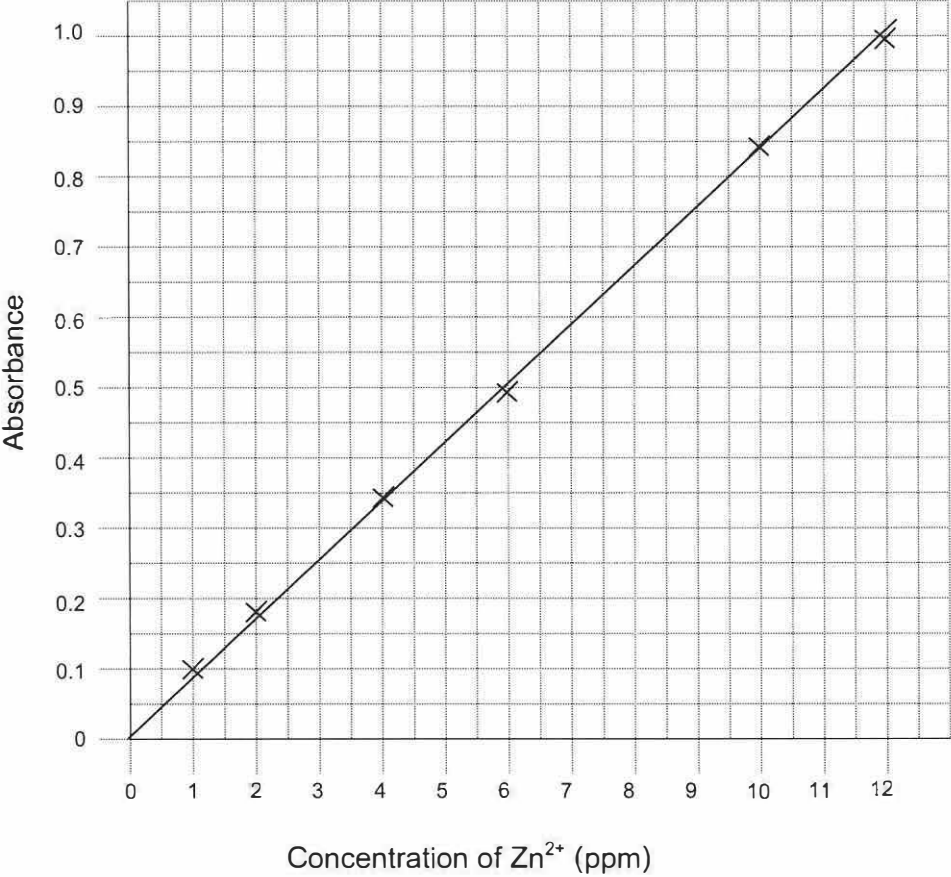
*2 bonus \$55 includes per-form*  
*Jacovaido*  
*The bromine alphabet*  
*value is lower*  
*it is the lower*  
*locant*

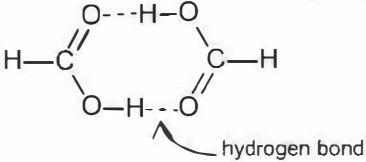
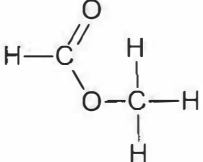
Question	Marking criteria	Marks allotted
21 (a) (i)	Correct structure drawn <div style="text-align: center;"> <pre>           H                     H-C-H                 H   C=C   C   C   C   H      \ /               /       H   H   H   H   H                               H   C   H                               H           </pre> </div>	1
(a) (ii)	C <sub>7</sub> H <sub>14</sub> OR correct formula for molecule drawn in (a) (i)	1
(b)	C <sub>7</sub> H <sub>14(l)</sub> + 10½O <sub>2(g)</sub> → 7CO <sub>2(g)</sub> + 7H <sub>2</sub> O <sub>(l)</sub> with states OR 2C <sub>7</sub> H <sub>14(l)</sub> + 21O <sub>2(g)</sub> → 14CO <sub>2(g)</sub> + 14H <sub>2</sub> O <sub>(l)</sub> with states OR Correct equation for formula given in (a) (ii) with states	1
(c)	Incomplete combustion of petrol is common and produces toxic CO/unburnt hydrocarbons Less incomplete combustion occurs with ethanol so less toxic emissions	1 1
22 (a)	Cu → Cu <sup>2+</sup> + 2e <sup>-</sup> Ag <sup>+</sup> + e <sup>-</sup> → Ag E = -0.34 + 0.80 = 0.46 V	½ ½ 1

Question	Marking criteria	Marks allotted
22 (b)	Correctly draws and labels an appropriate galvanic cell	3
	One aspect of the galvanic cell is incorrect OR a correct but inappropriate cell is drawn.	2
	One aspect of the galvanic cell is correct.	1
		
23 (a)	$n = \frac{V}{V_A} = \frac{2.02}{24.79} = 0.0815 \text{ mol (answer to 3 sig. figs.)}$	1
(b)	<p>Correct no. moles HX calculated AND Correct molar mass calculated  <math>2\text{HX} + \text{Na}_2\text{CO}_3 \rightarrow 2\text{NaX} + \text{H}_2\text{O} + \text{CO}_2</math>  <math>n(\text{CO}_2):n(\text{HX})=1:2 \therefore n(\text{HX})=2 \times 0.0815 = 0.163 \text{ mol}</math>  <math>M = \frac{m}{n} = \frac{7.50}{0.163} = 46.0 \text{ g/mol}</math></p>	2
	<p>Correct no. moles HX calculated OR Molar mass calculated from incorrect no. moles HX</p>	1
(c)	<p>Draws a structural formula consistent with the molar mass calculated in (b).</p> $\begin{array}{c} \text{O} \\ \parallel \\ \text{H}-\text{C} \\ \diagdown \\ \text{O}-\text{H} \end{array}$	1
24	<p>For each of two examples: Identifies a reason for nuclear instability and explains how this relates to the type of decay observed Includes a correct nuclear equation A nucleus can be unstable because it is too heavy (atomic number &gt; 83), neutron deficient, or neutron rich. For example, Am-241 has an atomic number &gt;83, and as a result will decay by alpha elimination. An alpha particle is a helium nucleus. As a result decaying by this mode means that the heavy nucleus is reduced in mass by 4 mass units. <math>{}_{95}^{241}\text{Am} \rightarrow {}_{93}^{237}\text{Np} + {}_2^4\text{He}</math> If a nucleus is neutron rich, such as Mg-27, the mode of decay is likely to be beta decay. In this mode of decay a neutron decays to an electron and a proton: <math>{}_0^1\text{n} \rightarrow {}_1^1\text{p} + {}_{-1}^0\text{e}</math>. As a result the ratio of neutrons to protons is reduced: <math>{}_{12}^{27}\text{Mg} \rightarrow {}_{13}^{27}\text{Al} + {}_{-1}^0\text{e}</math></p>	<p>2×1 2×1</p>



Question	Marking criteria	Marks allotted
25 (a)	Identifies a benefit of fluoridation of drinking water	1
(b)	Calculates mass of F <sup>-</sup> in 250 mL Maximum allowable = 1.5 mg/L; In 250 mL = 0.250 × 1.5 = 0.375 mg Calculates moles F <sup>-</sup> in 250 mL $n = \frac{m}{M} = \frac{0.375 \times 10^{-3}}{19.00} = 2.0 \times 10^{-5} \text{ mol}$	1 1
(c)	Describes two tests carried out on water for mass consumption, identifying what species is being monitored, and makes clear justification of each test	4
	Describes two tests carried out on water for mass consumption, identifying what species is being monitored	3
	Outlines tests carried out to monitor the quality of mass water supply	2
	Identifies one test carried out on mass water supply	1
26 (a)	Explains the meaning of amphiprotic Writes TWO correct equations to show H <sub>2</sub> PO <sub>4</sub> <sup>-</sup> is amphiprotic As an acid: $\text{H}_2\text{PO}_4^-(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{HPO}_4^{2-}(\text{aq})$ As a base: $\text{H}_2\text{PO}_4^-(\text{aq}) + \text{H}_3\text{O}^+(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{H}_3\text{PO}_4(\text{aq})$	1 1
(b)	Explains that the salt, potassium dihydrogen phosphate, is basic, as it reacts with water to form hydroxide ions Writes a correct equation showing H <sub>2</sub> PO <sub>4</sub> <sup>-</sup> forming hydroxide ions	1 1
27 (a)	Explains the changes in the curves resulting from changes in concentrations of chlorine, carbon monoxide and phosgene during the first 3 minutes Explains that the system is in equilibrium from 3 to 7 minutes and from 8 to 10 minutes Explains that extra carbon monoxide is added to the system at 7 minutes, resulting in an increase in the phosgene concentration	1 1 1
(b)	Predicts that the chlorine concentration will fall between 7 and 8 minutes Predicts it will remain steady from 8 to 10 minutes Explains the prediction in terms of the equilibrium shifting to the right OR by Le Chatelier's principle	½ ½ 1
28	Justifies the statement and includes a balanced equation Discusses the impacts of pressure and temperature on the rate of production of ammonia Discusses the impacts of pressure and temperature on the yield of ammonia Discusses the impacts of pressure and temperature on safety of the industrial process Discusses the impacts of pressure and temperature on economic viability of the industrial process	1 1 1 1 1

Question	Marking criteria	Marks allotted
29(a)	Draws a graph, using appropriate scales Plots all points correctly Draws a straight line of best fit   Concentration of Zn <sup>2+</sup> (ppm)	½ ½ 1
(b)	Correct answer (10.2-10.4 ppm)	1
(c)	Discusses the use of AAS in pollution control, particularly in control of heavy metal ion pollution AND Recognises that the use of AAS relates to the sensitivity of measurements	3
	Outlines the use of AAS in pollution control, particularly in control of heavy metal ion pollution AND Recognises that the use of AAS relates to the sensitivity of measurements	2
	Outlines the use of AAS in pollution control, particularly in control of heavy metal ion pollution OR Recognises that the use of AAS relates to the sensitivity of measurements	1

Question	Marking criteria	Marks allotted
30(a)	<p>Correctly uses structural formulae to represent methanoic acid or methyl methanoate</p> <p>Demonstrates the formation of H-bonding using structural formulae</p> <p>Relates the higher boiling point of methanoic acid to its ability to form H-bonds</p> <p>Methanoic acid forms hydrogen bonds between molecules</p>  <p>Methyl methanoate cannot form hydrogen bonds</p> 	<p>1</p> <p>1</p> <p>1</p>
(b)	<p>Identifies the use of heat as a way of increasing the rate of reaction</p> <p>Justifies refluxing as a way of safely heating a reaction (preventing loss of volatile components of reaction mixture)</p>	<p>1</p> <p>1</p>
31(a)	Correctly names the process as catalytic cracking	1
(b)	Correctly names the compound 2,2,4-trimethylheptane	1
(c)	<p>Compares the reactivities of alkanes and alkenes</p> <p>Identifies that the reaction is a type of addition reaction</p> <p>Writes a balanced equation for the hydration of ethene to give ethanol</p>	<p>1</p> <p>1</p> <p>1</p>

### Industrial Chemistry Option Marking Scheme

32 (a) (i)	For each of the TWO types of reactions: Describes a type of chemical reaction involving sulfuric acid Writes an appropriate equation	2×1 2×1
(ii)	Describes a valid procedure referring to reagents and conditions used Describes results obtained which indicated the reaction had taken place	1 1
(iii)	States two risks associated with the procedure States methods of controlling the named risks	2×½ 2×½
(iv)	Discusses the industrial production of sulfur trioxide from sulfur dioxide Uses Le Chatelier's principle and an appropriate equation to show how the equilibrium process is controlled	1 1
(b) (i)	Correct expression $K = \frac{[\text{CH}_3\text{OH}]}{[\text{CO}] \times [\text{H}_2]^2}$	1
(ii)	Correct determination of concentrations of the THREE species at equilibrium using the data from the graph $[\text{CH}_3\text{OH}] = 0.1 \text{ mol/10L} = 0.01 \text{ mol/L}$ $[\text{CO}] = 1.0 \text{ mol/10L} = 0.10 \text{ mol/L}$ $[\text{H}_2] = 0.9 \text{ mol/10L} = 0.09 \text{ mol/L}$ Correct answer (no units required) OR answer calculated from moles not concentration (K=0.12) $K = \frac{[\text{CH}_3\text{OH}]}{[\text{CO}] \times [\text{H}_2]^2} = \frac{0.01}{0.10 \times (0.09)^2} = 12.35... = 12$	1 1
(iii)	States correct change in equilibrium constant (will increase) Explains change in equilibrium constant (reaction is exothermic so a decrease in temperature from 500°C to 250°C will favour the forward reaction, increasing the concentration of methanol so the equilibrium constant will increase).	1 1
(c) (i)	Identifies a shrinking natural resource.	1
(ii)	Outlines two associated issues and identifies a current or potential solution	2
	Identifies two associated issues.	1
(d)	Correctly calculates the reaction quotient $Q = \frac{[\text{H}_2] \times [\text{CO}_2]}{[\text{CO}] \times [\text{H}_2\text{O}]} = \frac{0.35 \times 0.25}{0.55 \times 0.55} = 0.29$ Explains that the system is not at equilibrium by comparing the values of the reaction quotient to the equilibrium constant	1 1
(e) (i)	Identifies a relevant property of sulfur eg. low melting point/insolubility/density	1
(ii)	Describes the process used to melt the underground sulfur and form an emulsion transported to the surface Describes the extraction process used to separate the sulfur from the water.	1 1
(f)	Brine and limestone	2×1