



**SECTION A – Multiple-choice questions****Instructions for Section A**

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.

Choose the response that is **correct** or that **best answers** the question.

A correct answer scores 1, an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

**Question 1**

The flame test method of analysis can be used to distinguish between

- A. methanol and ethanol.
- B. sulfuric acid and nitric acid.
- C. lithium nitrate and calcium nitrate.
- D. sodium carbonate and sodium chloride.

**Question 2**

The molar volume of oxygen, in L, at 1.00 atmosphere and 100°C, is closest to

- A. 30.6
- B. 24.5
- C. 22.4
- D. 8.2

**Question 3**

Zinc metal reacts with 0.1 M hydrochloric acid to form hydrogen gas and zinc chloride solution.

The production of hydrogen gas is more vigorous if the zinc is powdered, rather than in large pieces, because the

- A. activation energy of the reaction is lower.
- B. activation energy of the reaction is higher.
- C. frequency of collisions between zinc metal and hydrogen ions is higher.
- D. fraction of reactant particles with sufficient energy to react is higher.

**Question 4**

Transport of oxygen in the body involves the complex molecules haemoglobin and oxyhaemoglobin.



If carbon monoxide (CO) is present in the air, poisoning can occur because

- A. the equilibrium constant,  $K$ , for the reaction is reduced.
- B. CO reacts with oxygen to form  $\text{CO}_2$ , driving the equilibrium to the left.
- C. the equilibrium shifts to the left because haemoglobin bonds strongly with CO.
- D. CO catalyses the decomposition of oxyhaemoglobin into haemoglobin and oxygen.

**Question 5**

Sulfuric acid ( $\text{H}_2\text{SO}_4$ ) and nitric acid ( $\text{HNO}_3$ ) are both strong acids. Ethanoic acid ( $\text{CH}_3\text{COOH}$ ) is a weak acid.

20.00 mL solutions of 0.10 M concentration of each of these three acids were separately titrated with a 0.10 M solution of sodium hydroxide (NaOH).

In order to react completely

- A. all three acids would require the same amount of NaOH.
- B.  $\text{HNO}_3$  would require more NaOH than  $\text{CH}_3\text{COOH}$  but less than  $\text{H}_2\text{SO}_4$ .
- C.  $\text{H}_2\text{SO}_4$  and  $\text{HNO}_3$  would require the same amount of NaOH but  $\text{CH}_3\text{COOH}$  would require less.
- D.  $\text{CH}_3\text{COOH}$  and  $\text{HNO}_3$  would require the same amount of NaOH but  $\text{H}_2\text{SO}_4$  would require more.

**Question 6**

A student used paper chromatography to separate two components, I and II, in a solution. A spot of the solution was initially placed at the origin.

When the spot corresponding to component I ( $R_f = 0.50$ ) had advanced 4.0 cm, the spot corresponding to component II was 1.0 cm behind.

The  $R_f$  value of component II is closest to

- A. 0.68
- B. 0.38
- C. 0.25
- D. 0.13

**Question 7**

Consider the molecule  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CHClCH}_2\text{CH}_3$ .

The systematic name of this molecule is

- A. 5-chloroheptane.
- B. 3-chloroheptane.
- C. 5-chlorooctane.
- D. 3-chlorooctane.

**Question 8**

The raspberry-flavoured food additive, butyl methanoate, can be prepared from  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$  using

- A. an addition reaction with  $\text{HCOOH}$ .
- B. an addition reaction with  $\text{CH}_3\text{COOH}$ .
- C. a condensation reaction with  $\text{HCOOH}$ .
- D. a condensation reaction with  $\text{CH}_3\text{COOH}$ .

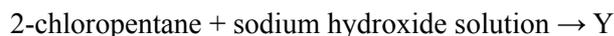
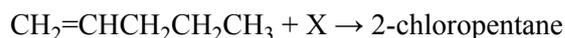
**Question 9**

The number of structural isomers that are carboxylic acids with the formula  $\text{C}_4\text{H}_8\text{O}_2$  is

- A. 1
- B. 2
- C. 3
- D. 4

**Question 10**

Two chemical reactions occur as follows.

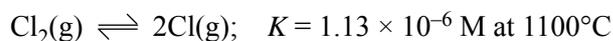


X and Y are given by

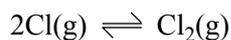
	X	Y
A.	Cl <sub>2</sub>	CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> CHOHCH <sub>3</sub>
B.	HCl	CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> CHOHCH <sub>3</sub>
C.	Cl <sub>2</sub>	CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> OH
D.	HCl	CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> OH

**Question 11**

Given the following information



what would be the numerical value of the equilibrium constant for the reaction



at the same temperature?

- A.  $8.85 \times 10^5$
- B.  $4.42 \times 10^5$
- C.  $2.26 \times 10^{-6}$
- D.  $1.13 \times 10^{-6}$

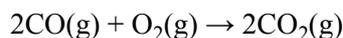
**Question 12**

The concentration of K<sup>+</sup> ions in 100 mL of 0.0500 M K<sub>2</sub>CO<sub>3</sub> solution, in g L<sup>-1</sup>, is

- A. 0.196
- B. 0.391
- C. 1.96
- D. 3.91

**Question 13**

Carbon monoxide can be oxidised to carbon dioxide.



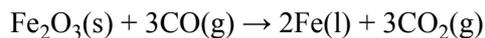
3 mol of CO and 2 mol of O<sub>2</sub> are mixed.

When the reaction is complete there will be

- A. 4 mol of CO<sub>2</sub> produced.
- B. 2 mol of CO<sub>2</sub> produced.
- C. 1 mol of CO unreacted.
- D. 0.5 mol of O<sub>2</sub> unreacted.

**Question 14**

The equation for a reaction that occurs during the extraction of iron from iron ore is



During this reaction the oxidation number of iron changes from

- A. +3 to 0, and CO is the reductant.
- B. +6 to 0, and CO is the reductant.
- C. +3 to 0, and CO is the oxidant.
- D. +6 to 0, and CO is the oxidant.

*Questions 15 and 16 refer to the following information.*

Methanol can be produced in a reaction between carbon monoxide and hydrogen according to the following equation.

**Question 15**

Which one of the following changes would occur when a catalyst is added to an equilibrium mixture of carbon monoxide, hydrogen and methanol?

- A. The value of  $\Delta H$  would increase.
- B. The amount of methanol would increase.
- C. The temperature of the surroundings would increase.
- D. The rates of both the forward and reverse reactions would increase.

**Question 16**

Which statement about the behaviour of a catalyst in this reaction is correct?

- A. It decreases the activation energy of the forward reaction only.
- B. It increases the activation energy of the forward reaction only.
- C. It decreases the activation energies of both the forward and back reactions.
- D. It increases the activation energies of both the forward and back reactions.

**Question 17**

Methanoic acid and ethanoic acid are both weak acids with the following acidity constants.

	$K_a$ in M at 25°C
methanoic acid (HCOOH)	$1.82 \times 10^{-4}$
ethanoic acid (CH <sub>3</sub> COOH)	$1.74 \times 10^{-5}$

Two separate solutions were prepared, one of 0.1 M methanoic acid and the other of 0.1 M ethanoic acid.

Which one of the following would be present in the highest concentration at 25°C?

- A. CH<sub>3</sub>COOH in the ethanoic acid solution
- B. CH<sub>3</sub>COO<sup>-</sup> in the ethanoic acid solution
- C. HCOOH in the methanoic acid solution
- D. HCOO<sup>-</sup> in the methanoic acid solution

**Question 18**

Consider the following information for the reaction  $A + B \rightarrow C$ .

heat of reaction  $-120 \text{ kJ mol}^{-1}$

activation energy  $+200 \text{ kJ mol}^{-1}$

The activation energy, in  $\text{kJ mol}^{-1}$ , for the reaction  $C \rightarrow A + B$ , is

- A.  $-320$
- B.  $-80$
- C.  $+80$
- D.  $+320$

**Question 19**

A short section of a polymer molecule is shown below.



This polymer could have been formed from

- A.  $\text{CF}_2\text{CH}_2$  only.
- B.  $\text{CF}_2\text{CF}_2$  and  $\text{CH}_2\text{CH}_2$ .
- C.  $\text{CF}_2\text{CF}_2$  and  $\text{CH}_2\text{CHCF}_3$ .
- D.  $\text{CH}_3\text{CHCF}_2$  and  $\text{CF}_3\text{CHCF}_2$ .

**Question 20**

The molecule  $\text{HOCH}_2\text{CH}_2\text{CH}_2\text{COOH}$  (molar mass =  $104 \text{ g mol}^{-1}$ ) forms a polymer in which the average polymer molecule contains 1000 monomer units.

The approximate molar mass of the polymer, in  $\text{g mol}^{-1}$ , is

- A. 68 000
- B. 86 000
- C. 95 000
- D. 104 000

**SECTION B – Short-answer questions****Instructions for Section B**

Answer **all** questions in the spaces provided.

To obtain full marks for your responses you should

- give simplified answers with an appropriate number of significant figures to all numerical questions; unsimplified answers will not be given full marks.
- show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.
- make sure chemical equations are balanced and that the formulas for individual substances include an indication of state; for example,  $\text{H}_2(\text{g})$ ;  $\text{NaCl}(\text{s})$

**Question 1**

A student was given four colourless liquids that were labelled **A**, **B**, **C** and **D**. They were known to be ethanol, ethanoic acid, pentane and hexene, but the exact identity of each liquid was unknown.

The student tested the properties of each liquid and obtained the following results.

	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
Solubility in water	insoluble	soluble	soluble	insoluble
Addition of red-coloured bromine ( $\text{Br}_2$ ) solution	colour disappears	no immediate reaction	no immediate reaction	no immediate reaction
Addition of sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) powder	no reaction	gas evolved	no reaction	no reaction

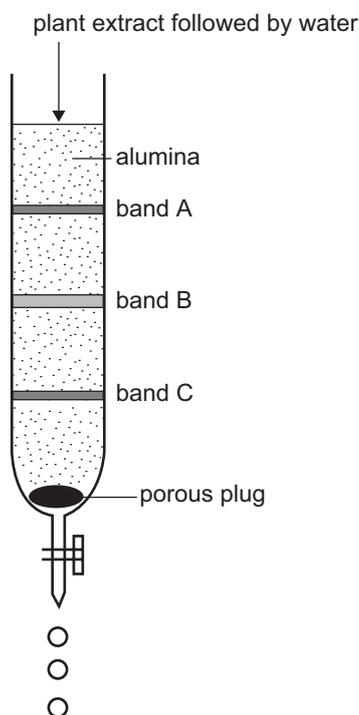
Identify each of the liquids by completing the table below.

	<b>Name of liquid</b>
<b>A</b>	
<b>B</b>	
<b>C</b>	
<b>D</b>	

Total 4 marks

**Question 2**

A burette packed with finely divided alumina powder ( $\text{Al}_2\text{O}_3$ ) was used to separate the components in a plant extract by chromatography. The alumina acts as the stationary phase and water was used as the mobile phase. A solution of the plant extract was placed at the top of the alumina and, once it had been adsorbed, further water was added periodically. The components separated as three coloured bands, as shown in the diagram below.



- a. i. In which one of the three bands, A, B or C, were the components most strongly adsorbed to the stationary phase?
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- ii. Band B starts to show signs of separating into two different bands just before it emerges from the bottom of the burette. Give one possible modification that could be made to this experiment to more effectively separate band B into its separate components.
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1 + 1 = 2 marks

- b. In another experiment, the components in the plant extract were separated in a similar way to paper chromatography, using a glass sheet coated with alumina and water as the mobile phase. Which one of the three bands, A, B or C, contains the component that would be most likely to have the smallest  $R_f$  value? Explain your answer.
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1 mark

- c. Which one of the three bands, A, B or C, contains the component that would have the smallest retention time if this separation was conducted using a high-performance liquid chromatograph with alumina as the stationary phase? Explain your answer.

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1 mark

Total 4 marks

**Question 3**

A soluble fertiliser contains phosphorus in the form of phosphate ions ( $\text{PO}_4^{3-}$ ). To determine the  $\text{PO}_4^{3-}$  content by gravimetric analysis, 5.97 g of the fertiliser powder was completely dissolved in water to make a volume of 250.0 mL. A 20.00 mL volume of this solution was pipetted into a conical flask and the  $\text{PO}_4^{3-}$  ions in the solution were precipitated as  $\text{MgNH}_4\text{PO}_4$ . The precipitate was filtered, washed with water and then converted by heating into  $\text{Mg}_2\text{P}_2\text{O}_7$ . The mass of  $\text{Mg}_2\text{P}_2\text{O}_7$  was 0.0352 g.

- a. Calculate the amount, in mole, of  $\text{Mg}_2\text{P}_2\text{O}_7$ .

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1 mark

- b. Calculate the amount, in mole, of phosphorus in the 20.00 mL volume of solution.

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1 mark

- c. Calculate the amount, in mole, of phosphorus in 5.97 g of fertiliser.

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1 mark

- d. Calculate the percentage of phosphate ions ( $\text{PO}_4^{3-}$ ) by mass in the fertiliser. Ensure you express your answer to an appropriate number of significant figures.

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3 marks

- e. i. Several actions which could occur during this analytical procedure are listed below (**A–D**). For each action, indicate the likely effect on the calculated percentage of phosphate ions in the fertiliser by placing a tick in the appropriate box.

Action	Calculated result would be too low	No effect on calculated result	Calculated result would be too high
<b>A.</b> The $\text{MgNH}_4\text{PO}_4$ precipitate was not washed with water.			
<b>B.</b> The conical flask had been previously washed with water but not dried.			
<b>C.</b> A 25.00 mL pipette was unknowingly used instead of a 20.00 mL pipette.			
<b>D.</b> The mass of the fertiliser was recorded incorrectly. The recorded mass was 0.2 g higher than the actual mass.			

- ii. In the case of action **B** above, explain your reasoning for the answer that you have given.

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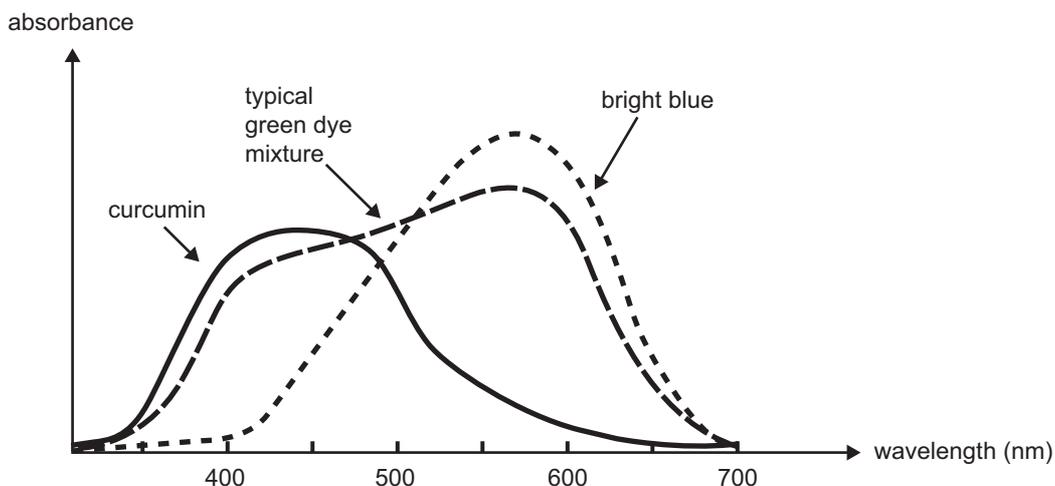
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4 + 1 = 5 marks

Total 11 marks

**Question 4**

A green dye used to colour tinned peas is made by mixing the yellow chemical, curcumin, with another colouring agent called bright blue. The individual spectra of curcumin, bright blue and a typical green dye mixture are represented below.



UV-visible spectroscopy is used to analyse the curcumin content of tinned peas.

- a. Circle the wavelength below which would be best used for absorbance measurements to determine the curcumin content of the peas.

400 nm      450 nm      500 nm      550 nm      600 nm      650 nm

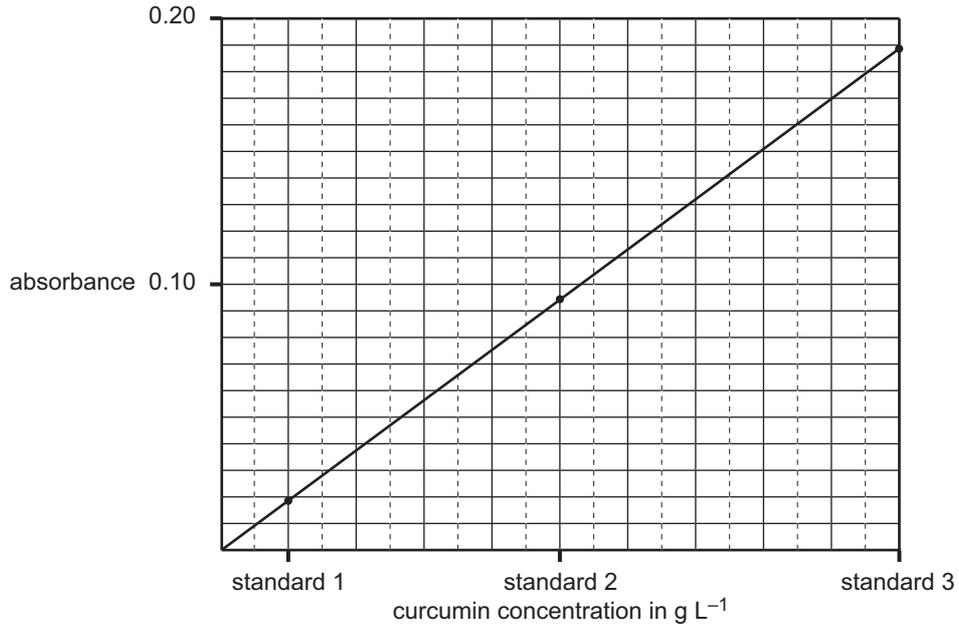
1 mark

- b. In one analysis, a stock solution of curcumin was prepared by dissolving 0.100 g of curcumin ( $C_{21}H_{20}O_6$ ; molar mass =  $368.0 \text{ g mol}^{-1}$ ) in 250.0 mL of water.

The stock solution was then diluted to make the following three standard solutions.

standard solution	curcumin concentration in $\text{g L}^{-1}$
standard 1	$1.00 \times 10^{-3}$
standard 2	$5.00 \times 10^{-3}$
standard 3	$1.00 \times 10^{-2}$

The absorbances of the standard solutions at the chosen wavelength were measured and the following calibration line was obtained.



- i. Calculate the concentration of curcumin in the stock solution in mol L<sup>-1</sup>.

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- ii. What volume of water must be added to 10.0 mL of the stock solution to make standard 3?

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- iii. The curcumin in a 9.780 g sample of peas was extracted into solution. The solution was filtered and made up to 100 mL in a volumetric flask. The absorbance of the solution at the wavelength used in the above calibration was found to be 0.170.

Calculate the curcumin content of the peas in milligram per gram of peas.

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2 + 2 + 3 = 7 marks

Total 8 marks

**SECTION B** – continued

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**Question 5**

a. The hydrogen carbonate ion ( $\text{HCO}_3^-$ ) can act both as an acid and as a base.

i. Write a chemical equation that shows  $\text{HCO}_3^-$  acting as an acid when it reacts with water.

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ii. Write a chemical equation that shows  $\text{HCO}_3^-$  acting as a base when it reacts with water.

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1 + 1 = 2 marks

b. Hypochlorous acid ( $\text{HOCl}$ ) is a weak acid with an acidity constant,  $K_a$ , of  $3.0 \times 10^{-8}$  M at  $25^\circ\text{C}$ . Calculate the pH of a 0.50 M solution of hypochlorous acid at that temperature.

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3 marks

c. The hydrogen ion concentration of a solution is described by the term pH. The hydroxide ion ( $\text{OH}^-$ ) concentration is described in the same way by the term pOH.

A solution has a pOH of 3 at  $25^\circ\text{C}$ .

i. Calculate the **hydroxide ion** concentration of the solution, in  $\text{mol L}^{-1}$ .

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ii. Calculate the **hydrogen ion** concentration of the solution, in  $\text{mol L}^{-1}$ .

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1 + 1 = 2 marks

Total 7 marks



**Question 7**

Petroleum is a complex mixture of hydrocarbons. The hydrocarbons are mainly alkanes of various carbon chain lengths.

- a. Write the name and molecular formula of an alkane which has nine carbon atoms.

Name \_\_\_\_\_

Molecular formula \_\_\_\_\_

1 mark

- b. Alkanes with short carbon chains boil at lower temperatures than long chain alkanes. Explain, in terms of bonding, why this is so.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

1 mark

- c. Briefly describe the fractional distillation process that is used for refining petroleum. You may use a fully labelled sketch to answer this question.

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\_\_\_\_\_

3 marks

- d. Another process in petroleum refining involves cracking. Some of the products of the cracking process are unsaturated hydrocarbons.
- i. When the gas propane ( $C_3H_8$ ) is cracked, several different products can be obtained. Write the formulas for four likely products of this process.

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- ii. Ethene is an example of an unsaturated hydrocarbon. Write equations for two chemical reactions in which ethene acts as a reactant.

Reaction 1 \_\_\_\_\_

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Reaction 2 \_\_\_\_\_

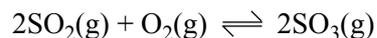
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2 + 2 = 4 marks

Total 9 marks

**Question 8**

One of the steps involved in the industrial preparation of sulfuric acid is the oxidation of sulfur dioxide to sulfur trioxide according to the equation

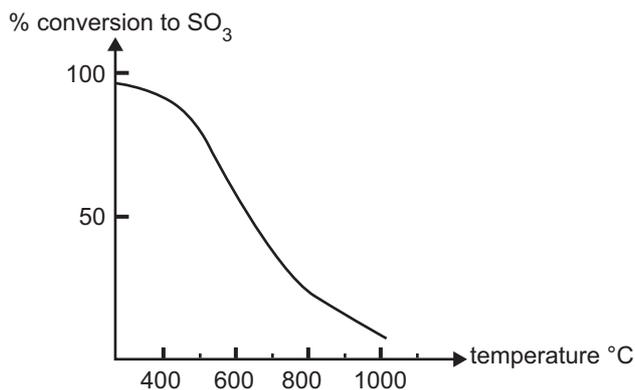


- a. Give the name or formula for the catalyst that is most widely used for this reaction.

\_\_\_\_\_

1 mark

- b. The graph below shows the percentage conversion of sulfur dioxide to sulfur trioxide at equilibrium at 1 atm pressure and various temperatures.



There is almost complete conversion of sulfur dioxide to sulfur trioxide at 300°C. However, this reaction is performed at a higher temperature of approximately 450°C in industry. Why?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

1 mark

- c. Explain why

- i. high pressures would increase the equilibrium yield of sulfur trioxide in this reaction.

\_\_\_\_\_  
\_\_\_\_\_

- ii. atmospheric pressure is **usually** used in industry, even though high pressures increase the equilibrium yield of sulfur trioxide in this reaction.

\_\_\_\_\_  
\_\_\_\_\_

1 + 1 = 2 marks

**d.** A chemical reaction that involves sulfuric acid occurs in each of the following situations. Write a balanced chemical equation for each reaction, showing the states of all reactants and products.

**i.** Dilute sulfuric acid is added to sodium carbonate solution.

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**ii.** Sulfur trioxide gas is bubbled through concentrated sulfuric acid.

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**iii.** A piece of zinc metal is added to 6 M sulfuric acid. Zinc ions are formed as well as an oxide of sulfur in which sulfur exhibits an oxidation state of +4.

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2 + 1 + 2 = 5 marks

Total 9 marks

# CHEMISTRY

## Written examination 1

### DATA SHEET

#### Directions to students

This data sheet is provided for your reference.

Make sure that you remove this data sheet from the centrefold during reading time.

Any writing, jottings, notes or drawings you make on this data sheet will **not** be considered in the marking.

At the end of the examination, make sure that you do **not** leave the data sheet in the centrefold of the question and answer book.

You may keep this data sheet.

**Physical constants**

$$F = 96\,500 \text{ C mol}^{-1}$$

$$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$$

$$1 \text{ atm} = 101\,325 \text{ Pa} = 760 \text{ mmHg}$$

$$0^\circ\text{C} = 273 \text{ K}$$

$$\text{Molar volume at STP} = 22.4 \text{ L mol}^{-1}$$

$$\text{Avogadro constant} = 6.02 \times 10^{23} \text{ mol}^{-1}$$

**Ideal gas equation**

$$pV = nRT$$

**The electrochemical series**

	$E^\circ$ in volt
$\text{F}_2(\text{g}) + 2\text{e}^- \rightarrow 2\text{F}^-(\text{aq})$	+2.87
$\text{H}_2\text{O}_2(\text{aq}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow 2\text{H}_2\text{O}(\text{l})$	+1.77
$\text{Au}^+(\text{aq}) + \text{e}^- \rightarrow \text{Au}(\text{s})$	+1.68
$\text{Cl}_2(\text{g}) + 2\text{e}^- \rightarrow 2\text{Cl}^-(\text{aq})$	+1.36
$\text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}(\text{l})$	+1.23
$\text{Br}_2(\text{l}) + 2\text{e}^- \rightarrow 2\text{Br}^-(\text{aq})$	+1.09
$\text{Ag}^+(\text{aq}) + \text{e}^- \rightarrow \text{Ag}(\text{s})$	+0.80
$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Fe}^{2+}(\text{aq})$	+0.77
$\text{I}_2(\text{s}) + 2\text{e}^- \rightarrow 2\text{I}^-(\text{aq})$	+0.54
$\text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) + 4\text{e}^- \rightarrow 4\text{OH}^-(\text{aq})$	+0.40
$\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s})$	+0.34
$\text{S}(\text{s}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2\text{S}(\text{g})$	+0.14
$2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$	0.00
$\text{Pb}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Pb}(\text{s})$	-0.13
$\text{Sn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Sn}(\text{s})$	-0.14
$\text{Ni}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Ni}(\text{s})$	-0.23
$\text{Co}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Co}(\text{s})$	-0.28
$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Fe}(\text{s})$	-0.44
$\text{Zn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Zn}(\text{s})$	-0.76
$2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$	-0.83
$\text{Mn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Mn}(\text{s})$	-1.03
$\text{Al}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Al}(\text{s})$	-1.67
$\text{Mg}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Mg}(\text{s})$	-2.34
$\text{Na}^+(\text{aq}) + \text{e}^- \rightarrow \text{Na}(\text{s})$	-2.71
$\text{Ca}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Ca}(\text{s})$	-2.87
$\text{K}^+(\text{aq}) + \text{e}^- \rightarrow \text{K}(\text{s})$	-2.93
$\text{Li}^+(\text{aq}) + \text{e}^- \rightarrow \text{Li}(\text{s})$	-3.02

## Periodic table of the elements

<b>1</b> <b>H</b> 1.0																	<b>2</b> <b>He</b> 4.0
<b>3</b> <b>Li</b> 6.9	<b>4</b> <b>Be</b> 9.0											<b>5</b> <b>B</b> 10.8	<b>6</b> <b>C</b> 12.0	<b>7</b> <b>N</b> 14.0	<b>8</b> <b>O</b> 16.0	<b>9</b> <b>F</b> 19.0	<b>10</b> <b>Ne</b> 20.1
<b>11</b> <b>Na</b> 23.0	<b>12</b> <b>Mg</b> 24.3											<b>13</b> <b>Al</b> 27.0	<b>14</b> <b>Si</b> 28.1	<b>15</b> <b>P</b> 31.0	<b>16</b> <b>S</b> 32.1	<b>17</b> <b>Cl</b> 35.5	<b>18</b> <b>Ar</b> 39.9
<b>19</b> <b>K</b> 39.1	<b>20</b> <b>Ca</b> 40.1	<b>21</b> <b>Sc</b> 44.9	<b>22</b> <b>Ti</b> 47.9	<b>23</b> <b>V</b> 50.9	<b>24</b> <b>Cr</b> 52.0	<b>25</b> <b>Mn</b> 54.9	<b>26</b> <b>Fe</b> 55.9	<b>27</b> <b>Co</b> 58.9	<b>28</b> <b>Ni</b> 58.7	<b>29</b> <b>Cu</b> 63.6	<b>30</b> <b>Zn</b> 65.4	<b>31</b> <b>Ga</b> 69.7	<b>32</b> <b>Ge</b> 72.6	<b>33</b> <b>As</b> 74.9	<b>34</b> <b>Se</b> 79.0	<b>35</b> <b>Br</b> 79.9	<b>36</b> <b>Kr</b> 83.8
<b>37</b> <b>Rb</b> 85.5	<b>38</b> <b>Sr</b> 87.6	<b>39</b> <b>Y</b> 88.9	<b>40</b> <b>Zr</b> 91.2	<b>41</b> <b>Nb</b> 92.9	<b>42</b> <b>Mo</b> 95.9	<b>43</b> <b>Tc</b> 98.1	<b>44</b> <b>Ru</b> 101.1	<b>45</b> <b>Rh</b> 102.9	<b>46</b> <b>Pd</b> 106.4	<b>47</b> <b>Ag</b> 107.9	<b>48</b> <b>Cd</b> 112.4	<b>49</b> <b>In</b> 114.8	<b>50</b> <b>Sn</b> 118.7	<b>51</b> <b>Sb</b> 121.8	<b>52</b> <b>Te</b> 127.6	<b>53</b> <b>I</b> 126.9	<b>54</b> <b>Xe</b> 131.3
<b>55</b> <b>Cs</b> 132.9	<b>56</b> <b>Ba</b> 137.3	<b>57</b> <b>La</b> 138.9	<b>72</b> <b>Hf</b> 178.5	<b>73</b> <b>Ta</b> 180.9	<b>74</b> <b>W</b> 183.8	<b>75</b> <b>Re</b> 186.2	<b>76</b> <b>Os</b> 190.2	<b>77</b> <b>Ir</b> 192.2	<b>78</b> <b>Pt</b> 197.0	<b>79</b> <b>Au</b> 197.0	<b>80</b> <b>Hg</b> 200.6	<b>81</b> <b>Tl</b> 204.4	<b>82</b> <b>Pb</b> 207.2	<b>83</b> <b>Bi</b> 209.0	<b>84</b> <b>Po</b> (209)	<b>85</b> <b>At</b> (210)	<b>86</b> <b>Rn</b> (222)
<b>87</b> <b>Fr</b> (223)	<b>88</b> <b>Ra</b> (226)	<b>89</b> <b>Ac</b> (227)	<b>104</b> <b>Rf</b> (261)	<b>105</b> <b>Db</b> (262)	<b>106</b> <b>Sg</b> (263)	<b>107</b> <b>Bh</b> (264)	<b>108</b> <b>Hs</b> (265)	<b>109</b> <b>Mt</b> (268)	<b>110</b> <b>Uun</b>	<b>111</b> <b>Uuu</b>	<b>112</b> <b>Uub</b>		<b>114</b> <b>Uuq</b>		<b>116</b> <b>Uuh</b>		<b>118</b> <b>Uuo</b>

<b>58</b> <b>Ce</b> 140.1	<b>59</b> <b>Pr</b> 140.9	<b>60</b> <b>Nd</b> 144.2	<b>61</b> <b>Pm</b> (145)	<b>62</b> <b>Sm</b> 150.3	<b>63</b> <b>Eu</b> 152.0	<b>64</b> <b>Gd</b> 157.2	<b>65</b> <b>Tb</b> 158.9	<b>66</b> <b>Dy</b> 162.5	<b>67</b> <b>Ho</b> 164.9	<b>68</b> <b>Er</b> 167.3	<b>69</b> <b>Tm</b> 168.9	<b>70</b> <b>Yb</b> 173.0	<b>71</b> <b>Lu</b> 175.0
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<b>90</b> <b>Th</b> 232.0	<b>91</b> <b>Pa</b> 231.0	<b>92</b> <b>U</b> 238.0	<b>93</b> <b>Np</b> 237.1	<b>94</b> <b>Pu</b> (244)	<b>95</b> <b>Am</b> (243)	<b>96</b> <b>Cm</b> (247)	<b>97</b> <b>Bk</b> (247)	<b>98</b> <b>Cf</b> (251)	<b>99</b> <b>Es</b> (254)	<b>100</b> <b>Fm</b> (257)	<b>101</b> <b>Md</b> (258)	<b>102</b> <b>No</b> (259)	<b>103</b> <b>Lr</b> (260)
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