SECTION I
75 marks

Part A – 20 marks
Attempt all 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:

A ⊗ B ⊗ ← C ○ D ○

1. 1-hexene may be formed from the cracking of petroleum compounds. Which equation represents formation of 1-hexene from the catalytic cracking of a very high boiling point distillation product of petroleum refining?

(A) $C_8H_{16} \rightarrow C_2H_4 + C_6H_{12}$

(B) $C_{11}H_{24} \rightarrow C_6H_{14} + C_5H_{10}$

(C) $C_{18}H_{38} \rightarrow C_{12}H_{26} + C_6H_{12}$

(D) $C_{26}H_{54} \rightarrow C_{20}H_{40} + C_6H_{14}$

2. Phenylethene (benzyl ethene) is used to form a polymer having which set of properties?

	Hardness	Flexibility	Heat resistance
(A)	hard	very flexible	low melting point
(B)	hard	inflexible	high melting point
(C)	medium	very flexible	low melting point
(D)	soft	inflexible	high melting point

3. Which of the following metals in the elemental state would have the greatest tendency to reduce iron (III) in aqueous solution?

(A) copper

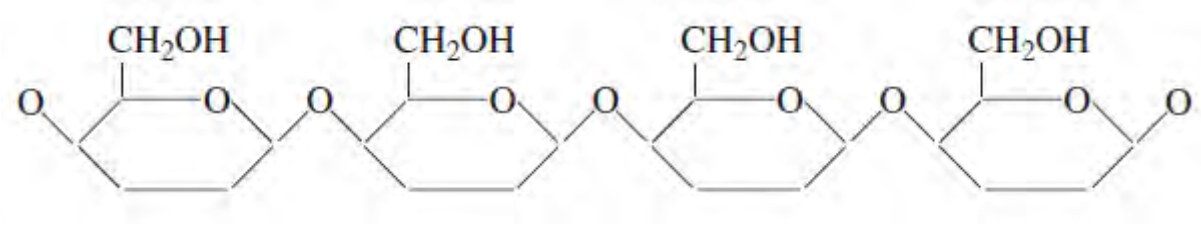
(B) iron

(C) manganese

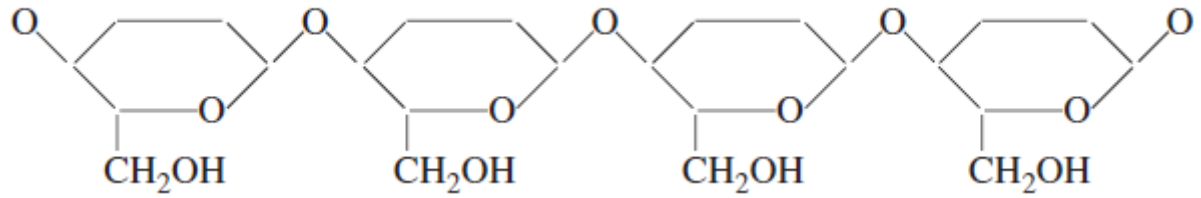
(D) silver

4. Which diagram displays a four-monomer segment of cellulose?

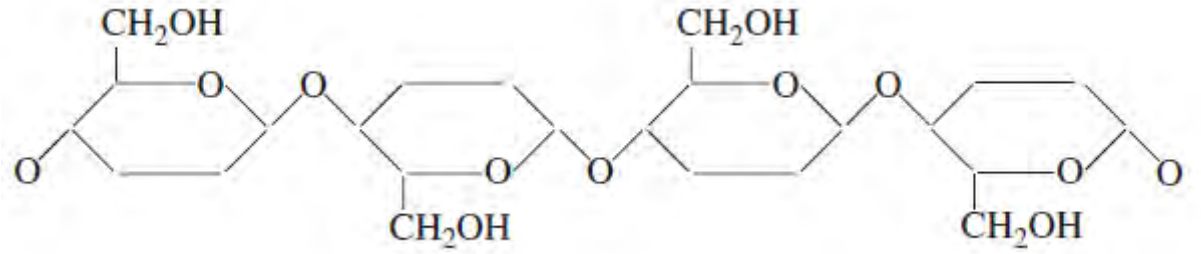
(A)



(B)



(C)



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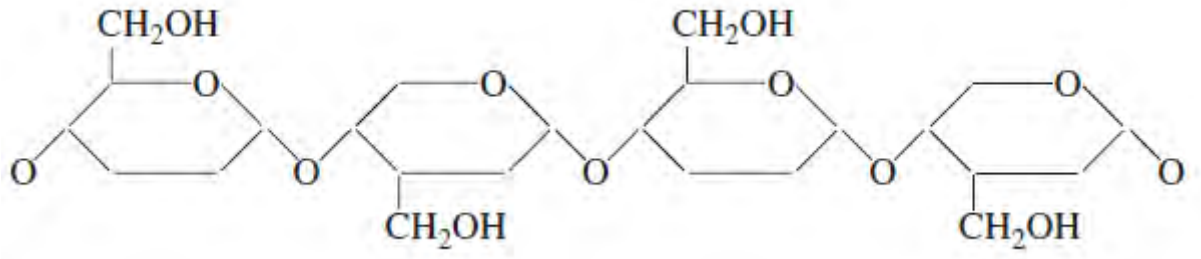

5. Ethanol is widely used as a solvent.What is one limitation of ethanol as a solvent for non-polar substances?

(A) Ethanol is a suitable solvent only for small hydrocarbons due to the amount of dispersion forces that can be formed.

(B) Ethanol is a suitable solvent only for small hydrocarbons due to the amount of hydrogen bonding that can be formed.

(C) Ethanol is a suitable solvent only for long hydrocarbons due to the amount of dispersion forces that can be formed.

(D) Ethanol is a suitable solvent only for medium-length hydrocarbons due to the amount of hydrogen bonding that can be formed.

6. A student constructs a galvanic cell in order to measure the cell potential for the reaction between lead and aluminium under standard conditions. What is the cell potential $E^{\ominus}$ (e.m.f.) for the cell?

(A) -1.81 V

(B) 1.81 V

(C) 1.55 V

(D) 2.97 V

7. Sodium chromate may be formed by reacting hydrogen peroxide with sodium chromite in alkaline conditions as shown below.

$$2NaCrO_2\ (aq) + 3H_2O_2\ (aq) + 2NaOH\ (aq) \rightarrow 2Na_2CrO_4\ (aq) + 4H_2O\ (l)$$

What changes to the oxidation state of chromium has occurred in this reaction?

	Reactants	Products
(A)	-1	-2
(B)	0	+4
(C)	+3	+6
(D)	+4	+8

8. Chromate (CrO_4^{2-}) and dichromate($Cr_2O_7^{2-}$) ions form an equilibrium mixture as represented in the equation:

$2CrO_4^{2-}\ (aq) + 2H^+\ (aq) \rightleftharpoons Cr_2O_7^{2-}\ (aq) + H_2O\ (l)$

Which of the following solutions, when added to the equilibrium mixture, would decrease the concentration of the dichromate ions?

(A) Sodium chloride

(B) Hydrochloric acid

(C) Acetic acid

(D) Sodium acetate

9. The scientist(s) who first classified acids as 'substances which produced hydrogen gas when electrolysed or after reaction with certain metals' was/were

(A) Arrhenius

(B) Davy

(C) Lowry and Bronsted

(D) Lavoisier

10. An aqueous solution was tested in the laboratory with various indicators. The results of the testing are displayed below.

Indicator used	Colour of solution with indicator added
Phenolphthalein	Colourless
Methyl orange	Yellow
Bromothymol blue	Yellow

From these results, it is possible to conclude that the solution

(A) is highly acidic.

(B) is highly alkaline.

(C) is slightly acidic.

(D) could be slightly acidic, neutral or alkaline.

11. Sulfur dioxide is classified as

(A) an acidic oxide, because it reacts with acids to form salts.

(B) a basic oxide, because it produces hydroxide ions in aqueous solution.

(C) an acidic oxide, because it reacts with bases to form salts.

(D) a basic oxide, because it is neutralised by acids.

12. Which action would have the greatest increase in the pH of the solution?

(A) Diluting 10.0 mL of 0.01 mol L^{-1} HCl *(aq)* to 40.0 mL

(B) Diluting 10.0 mL of 0.01 mol L^{-1} NaOH *(aq)* to 40.0 mL

(C) Diluting 10.0 mL of 0.01 mol L^{-1} HCl *(aq)* to 1000.0 mL

(D) Diluting 10.0 mL of 0.01 mol L^{-1} NaOH *(aq)* to 1000.0 mL

13. Which of the following species is a conjugate base of a strong acid?

(A) Cl^-

(B) CH_3COO^-

(C) NO_3^{2-}

(D) OH^-

14. Four monoprotic acids, W, X, Y and Z were tested and the following data collected:

Acid	Concentration (mol/L)	pH
W	0.01	2.0
X	0.01	3.8
Y	0.10	3.5
Z	0.05	1.35

Which one is the weakest acid?

(A) W

(B) X

(C) Y

(D) Z

15. A car engine burns petrol with insufficient air. Which substance would be emitted in the exhaust in higher levels than from an engine with the correct fuel to air ratio?

(A) Carbon monoxide

(B) Sulfur dioxide

(C) Nitrogen monoxide

(D) Carbon dioxide

16. In the production of ammonia using the Haber process, which of the following statements is INCORRECT?

(A) At equilibrium, the yield is higher when the temperature is lower.

(B) Before reaching equilibrium, the rate is higher at a higher temperature.

(C) The rate of the reaction is lower at a higher temperature because the reaction is exothermic.

(D) At equilibrium, the yield is lower at a lower pressure.

17. Solutions containing lead ions were analysed by AAS. A standard aqueous solution of 10 ppm lead had an absorbance of 0.3. A second solution of unknown concentration was found to have an absorbance of 0.6.

100 ml of this second solution was reacted with excess potassium iodide solution. The precipitate was then washed, dried and weighed.

What was the mass of precipitate formed?

(A) 4.45g

(B) 4.5×10^{-3}g

(C) 0.002g

(D) 2.45×10^{-3}g

18. A solution was known to contain either sodium nitrate, sodium carbonate or sodium chloride. Samples of the solution gave bubbles of gas after adding $HNO_3(aq)$, and no precipitate was observed when $NH_4NO_3(aq)$ was added. What anion was present in the original solution?

(A) Cl^{-1}

(B) NO_3^{-1}

(C) SO_4^{-2}

(D) CO_3^{-2}

19. The concentration of ozone in the troposphere is 0.000003% (v/v). What is this concentration in parts per million?

(A) 0.0003

(B) 0.03

(C) 0.003

(D) 0.000003

20. How many isomers are there for C_3H_6BrCl?

(A) 3

(B) 4

(C) 5

(D) 6

Student Name	
Teacher	
Mark /	

Write your Name and Teacher at the top of this Part B Answer Booklet.

SECTION I (continued)
Part B – 55 Marks
Attempt all questions 21-33
Allow about 1 hour and 35 minutes for this part
Show all relevant working in questions involving calculations

Question 21 (3 marks)

Explain the use of one named radioactive isotope in industry in terms of its properties.

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Question 22 (3 marks)

Describe the conditions and chemistry associated with two different ways of forming ethanol.

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Question 23 (2 marks)

A 3.510 g sample of 1-propanol is combusted in heating a certain mass of water from 25^{o}C to 45^{o}C. 70.00 % of the heat released is absorbed by the water. The molar heat of combustion of 1-propanol is 2016 kJ mol^{-1}. What was the quantity of water heated?

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Question 24 (3 marks)

Assess the potential of ethanol as an alternative fuel.

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Question 25 (2 marks)

A student was asked to perform a first-hand investigation to compare the reactivities of hexane and 1-hexene by observing their reactions with bromine water.

(a) Describe the reaction(s) observed by the student when the procedures were carried out in a darkened laboratory. (1 mark)

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(b) Write an equation to show any addition reaction(s) that occurred. (1 mark)

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Question 26 (7 Marks)

A standard solution of sodium carbonate (Na_2CO_3) was prepared by dissolving 5.46 g of the solid in water and making the volume up to 500.0 mL in a volumetric flask.

(a) Determine the concentration of the standard solution in mol L^{-1}. (1 mark)

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(b) Explain why sodium carbonate can be used to make a primary standard solution whereas sodium hydroxide is **NOT** appropriate for use as a primary standard. (2 marks)

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Question 26 *Continued*

(c) Lillian analysed the acetic acid content of vinegar using a titration. She took 20 mL of the white vinegar and diluted it systematically to 100 mL.

(i) Lillian transferred 25.00 mL of the diluted vinegar to a conical flask. Name the piece of glassware she used for this procedure. (1mark)

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(ii) The diluted vinegar was titrated with 0.105 mol/L potassium hydroxide solution and the end point was reached with an average titre of 31.8 mL of the base. Identify from the following table suitable indicators for Kylie's titration and calculate the concentration of the acetic acid in the diluted vinegar. (3 marks)

Indicator	pH range
meta-cresol purple	1.2–2.8
bromophenol blue	3.0–4.6
congo red	3.0–5.0
bromophenol red	5.2–6.8
neutral red	6.8–8.0
thymol blue	8.0–9.6

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Question 27 (4 marks)

Assess the use of sodium hydrogen carbonate as a safety measure in laboratories or to minimise damage in accidents or chemical spills.

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Question 28 (6 marks)

A student prepared an ester in the school laboratory by heating formic acid and propanol with a suitable catalyst under reflux.

(a) Draw a labelled diagram of the apparatus used for the reflux stage of this experiment. (2 marks)

(b) Justify **TWO** reasons for the use of heating under reflux during this experiment. (2 marks)

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(c) Write the balanced structural formula equation for the esterification using the reactants given in part **(a).** (2 marks)

Question 29 (6 marks)

The table below shows the solubility of carbon dioxide in water at various temperatures.

Temperature (°C)	Solubility (g of CO_2 per 100 g water)
0	0.320
10	0.220
20	0.170
30	0.130
40	0.095

(a) Use the grid below to graph these results. (2 marks)

(b) The dissolving of carbon dioxide in water involves an equilibrium reaction. Write an equation to represent the equilibrium reaction. (1 mark)

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(c) Use the data in the table (on the previous page) to explain whether the equation you have written in part (b) is endothermic or exothermic. (1 mark)

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(d) A test for carbon dioxide involves bubbling the gas through limewater and observing the formation calcium carbonate as described by the following reaction.

$$Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$$

Calculate the mass of carbon dioxide gas needed to produce 0.25 g of calcium carbonate by this reaction. (2 marks)

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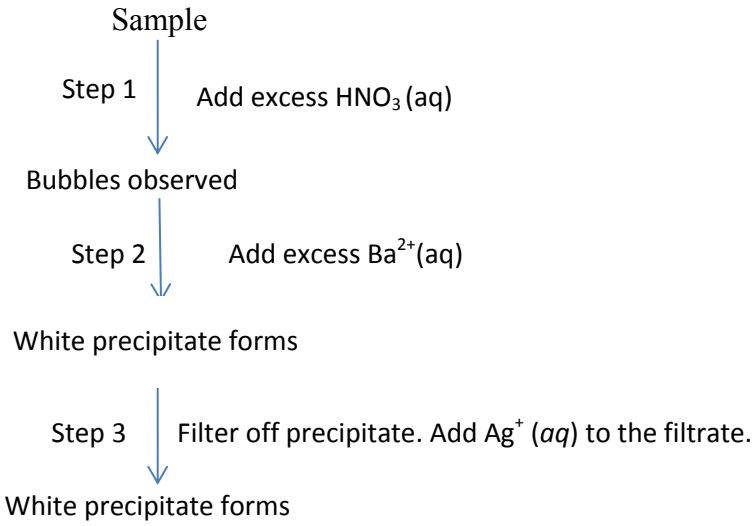
Question 30 (5 marks)

A student performed a series of tests using the following flow chart to identify the anions present in a given sample.



(a) Identify the three anions present in the sample. Write net ionic equations to describe how the anion was identified at each step. (3 marks)

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Step 1: . . . . . .

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Step 2: . . . . . .

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Step 3: . . . . . .

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(b) A sample of 3.150g of a soluble lawn fertilizer was analysed for its sulfate content by gravimetric analysis. The mass of barium sulfate collected was 3.325g. Calculate the percentage by weight of sulfate in the fertiliser. (2 marks)

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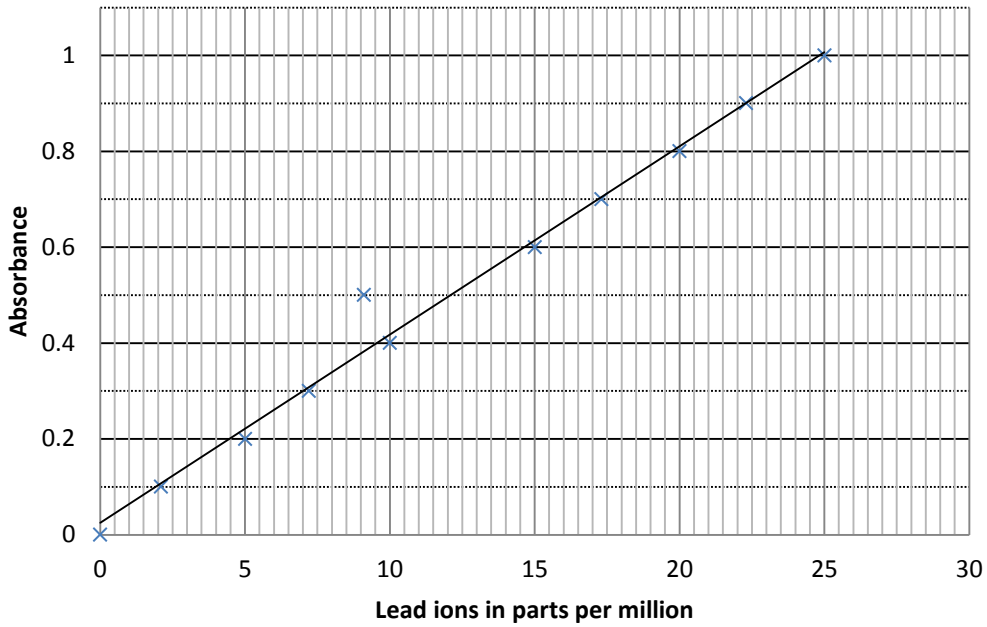
Question 31 (6 marks)

A scientist decided to measure the concentration of lead (Pb) in the soil around an old paint factory site. He used the calibration graph below to determine the concentration of lead (II) ions in a soil sample that gave an absorbance reading of 0.7.



(a) Determine the concentration of the lead (II) ions in the soil sample in grams per litre. (1mark)

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Question 31 continues on the next page

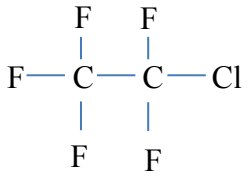
Question 31 *Continued*

(b) Evaluate the effectiveness of AAS in the detection of a trace element like lead and in safeguarding the environment. (5 marks)

Question 32 (5 marks)

Human activity has reduced the concentration of ozone in the upper atmosphere.

(a) Give the systematic name of the compound below. (1 mark)



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(b) Describe how a compound such as that shown in part (a) can destroy ozone. Support your answer with chemical equations. (4 marks)

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Question 33(3 marks)

Evaluate reasons for concern about the release of the oxides of sulphur and nitrogen into the environment.

Write your Name and Class at the top of the Section II Answer Booklet.

SECTION II

25 marks

Attempt ALL parts of Question 34 Industrial Chemistry - Parts (a) – (e)

Allow about 45 minutes for this part

Show all relevant working in questions involving calculations

Answer the question parts in the Section II Answer Booklet. Extra writing booklets are available.

Question 33 - Industrial Chemistry (25 Marks)

(a) Identify one natural product that is not a fossil fuel, and discuss how the issues associated with shrinking reserves have been, or are being, addressed. **(3 marks)**

(b) Gaseous hydrogen bromide partially decomposes to form hydrogen and bromine according to the following equation:

$$2HBr\ (g) \leftrightarrows H_2\ (g) + Br_2\ (g)$$

At 450K, the equilibrium constant for the decomposition reaction is 0.0575.

Some hydrogen bromide gas was placed in an evacuated 3.00 L vessel and heated to 450K. When the system had reached equilibrium, the equilibrium concentration of hydrogen was found to be 9.50×10^{-4} mol L^{-1}.

(i) Write the equilibrium constant expression for the decomposition reaction. (**1 mark**)

(ii) Calculate the concentration of gaseous bromine in the equilibrium mixture at 450K. (**1 mark**)

(iii) Calculate the concentration of gaseous hydrogen bromide in the equilibrium mixture at 450K. (**2 marks**)

(iv) Predict and explain the effect on the equilibrium mixture if a suitable catalyst is added to the reaction vessel at 450K. (**2 marks**)

(c) (i) Identify a range of fats and oils used for soap making. **(2 marks)**

(ii) Compare and contrast the conditions under which saponification can be performed in the school laboratory with the industrial preparation. **(3 marks)**

Question 33 continues on the next page

(d) (i) With the aid of labelled diagrams, outline the cleaning action of soaps. **(3 marks)**

(ii) Account for a use of an emulsion in terms of its properties. **(2 marks)**

(e) Synthetic detergents have been developed over the past 60 years. Compare anionic, cationic and non-ionic synthetic detergents in terms of their use and chemical composition and the impact that these detergents have had on the environment. **(6 marks)**

END OF TRIAL EXAMINATION

Name: Teacher:

SECTION I
75 marks

Part A – 20 marks
Attempt all 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:

A ⊗ B ⊗ ← C ○ D ○

Name: Teacher:

1. 1-hexene may be formed from the cracking of petroleum compounds. Which equation represents formation of 1-hexene from the catalytic cracking of a high boiling point distillation product of petroleum refining?

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(B) $C_{11}H_{24} \rightarrow C_6H_{14} + C_5H_{10}$

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	Hardness	Flexibility	Heat resistance
(A)	hard	very flexible	low melting point
(B)	**hard**	**inflexible**	**high melting point**
(C)	medium	very flexible	low melting point
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3. Which of the following metals in the elemental state would have the greatest tendency to reduce iron (III) in aqueous solution?

(A) copper

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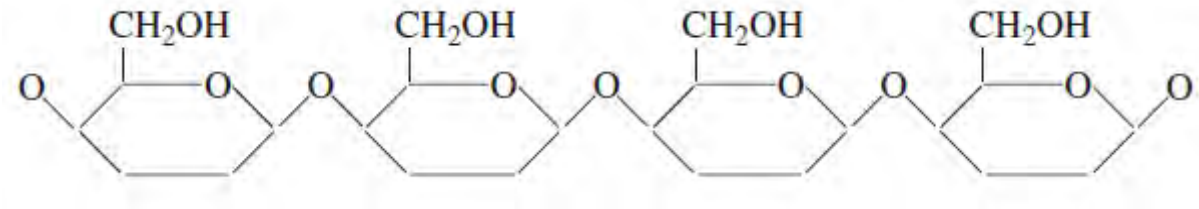
(D) silver

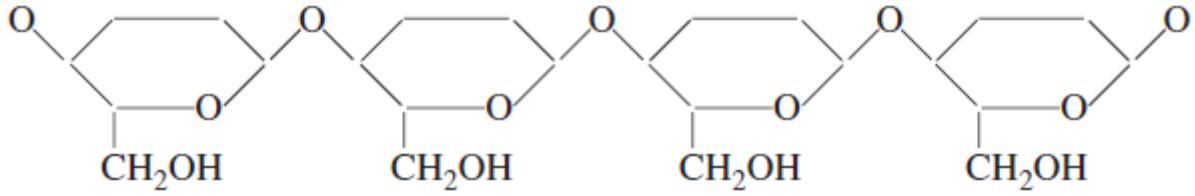
Name: Teacher:

4. Which diagram displays a four-monomer segment of cellulose?

(A)



(B)



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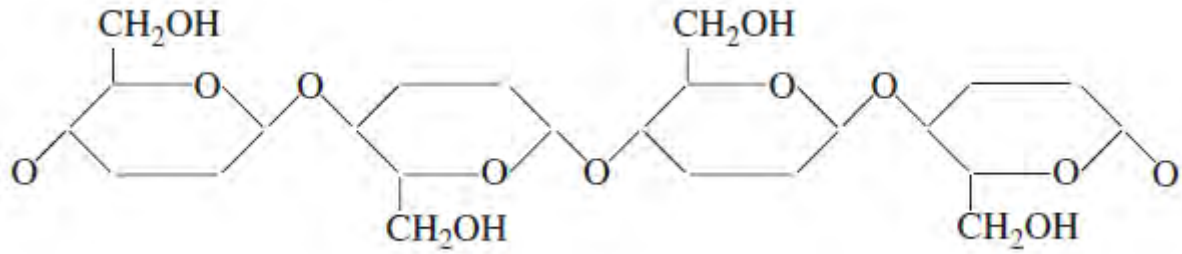

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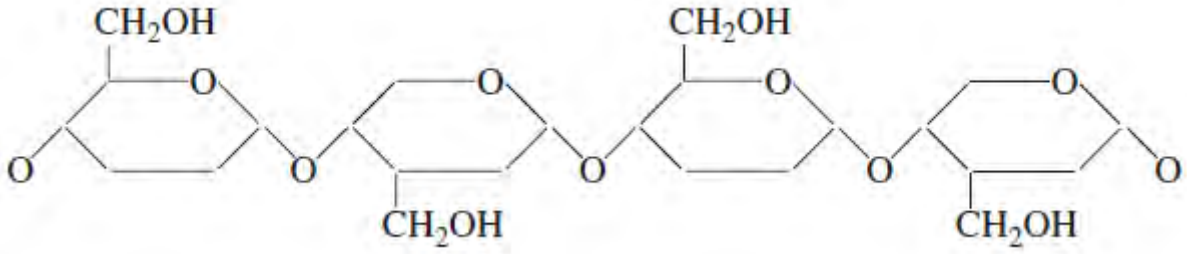


5. Ethanol is widely used as a solvent.What is one limitation of ethanol as a solvent for non-polar substances?

(A) Ethanol is a suitable solvent only for small hydrocarbons due to the amount of dispersion forces that can be formed.

(B) Ethanol is a suitable solvent only for small hydrocarbons due to the amount of hydrogen bonding that can be formed.

(C) Ethanol is a suitable solvent only for long hydrocarbons due to the amount of dispersion forces that can be formed.

(D) Ethanol is a suitable solvent only for medium-length hydrocarbons due to the amount of hydrogen bonding that can be formed.

6. A student constructs a galvanic cell in order to measure the cell potential for the reaction between lead and aluminium under standard conditions. What is the cell potential $E^{\ominus}$ (e.m.f.) for the cell?

(A) -1.81 V

(B) 1.81 V

(C) 1.55 V

(D) 2.97 V

7. Sodium chromate may be formed by reacting hydrogen peroxide with sodium hypochromate in alkaline conditions as shown below.

$$2NaCrO_2\ (aq) + 3H_2O_2\ (aq) + 2NaOH\ (aq) \rightarrow 2Na_2CrO_4\ (aq) + 4H_2O\ (l)$$

What changes to the oxidation state of chromium has occurred in this reaction?

	Reactants	Products
(A)	-1	-2
(B)	0	+4
(C)	**+3**	**+6**
(D)	+4	+8

8 Chromate and dichromate ions form an equilibrium mixture as represented in the equation:

$2CrO_4^{2-}\ (aq) + 2H^+\ (aq) \rightleftharpoons Cr_2O_7^{2-}\ (aq) + H_2O\ (l)$

Which of the following solutions, when added to the equilibrium mixture, would decrease the concentration of the dichromate ions?

(A) Sodium chloride

(B) Hydrochloric acid

(C) Acetic acid

(D) **Sodium acetate**

9 The scientist(s) who first classified acids as 'substances which produced hydrogen gas when electrolysed or after reaction with certain metals' was/were

(A) Arrhenius

(B) **Davy**

(C) Lowry and Bronsted

(D) Lavoisier

10 An aqueous solution was tested in the laboratory with various indicators, as shown below.

Indicator	Colour
Phenolphthalein	Colourless
Methyl orange	Yellow
Bromothymol blue	Yellow

From these results, it is possible to conclude that the solution

(A) is neutral.

(B) is weakly alkaline.

(C) **is weakly acidic**.

(D) could be weakly acidic, neutral or weakly alkaline.

11

Sulfur dioxide is classified as

(A) an acidic oxide, because it reacts with acids to form salts.

(B) a basic oxide, because it produces hydroxide ions in aqueous solution.

(C) **an acidic oxide, because it reacts with bases to form salts.**

(D) a basic oxide, because it is neutralised by acids.

12 Which action would result in an increase of TWO pH units of the solution?

(A) Diluting 10.0 mL of 0.01 mol L^{-1} HCl *(aq)* to 40.0 mL

(B) Diluting 10.0 mL of 0.01 mol L^{-1} NaOH *(aq)* to 40.0 mL

(C) **Diluting 10.0 mL of 0.01 mol L^{-1} HCl *(aq)* to 1000.0 mL**

(D) Diluting 10.0 mL of 0.01 mol L^{-1} NaOH *(aq)* to 1000.0 mL

13 Which of the following mixtures could be used as a buffer solution?

(A) 1.0 L of 0.10 mol L^{-1} methanoic acid and 1.0 L of 0.10 mol L^{-1} sodium hydroxide solutions

(B) 1.0 L of 0.10 mol L^{-1} ethanoic acid and 1.00 mL of 0.10 mol L^{-1} sodium ethanoate solutions

(C) 1.0 L of 0.10 mol L^{-1} hydrochloric acid and 1.0 L of 0.10 mol L^{-1} sodium hydroxide solutions

(D) **1.0 L of 0.10 mol L^{-1} methanoic acid and 1.0 L of 0.10 mol L^{-1} sodium methanoate solutions**

14 What is the pH of the resulting solution when 50.0 mL of 0.15 mol L^{-1} sodium hydroxide solution and 150 mL of 0.10 mol L^{-1} sulfuric acid are mixed?

(A) **0.95**

(B) 2.12

(C) 1.4

(D) 1.65

15. A car engine burns fuel with insufficient air. Which substance would be emitted in the exhaust in higher levels than from an engine with the correct fuel to air ratio?

(A) Carbon monoxide

(B) Sulfur dioxide

(C) Nitrogen monoxide

(D) Carbon dioxide

16. In the production of ammonia using the Haber process, which of the following statements is incorrect?

(A) At equilibrium, the yield is higher when the temperature is lower.

(B) Before reaching equilibrium, the rate is higher at a higher temperature.

(C) The rate of the reaction is lower at a higher temperature because the reaction is exothermic.

(D) At equilibrium, the yield is lower at a lower pressure.

17. Solutions containing lead ions were analysed by AAS. A standard solution of 10 ppm lead had an absorbance of 0.3. A second solution of unknown concentration was found to have an absorbance of 0.6.
100 ml of this second solution was reacted with excess potassium iodide solution. The precipitate was then washed, dried and weighed. What was the mass of precipitate formed?

(A) 4.45g

(B) 4.5×10^{-3}g

(C) 0.002g

(D) 2.45×10^{-3}g

18. A solution was known to contain either sodium carbonate or sodium chloride. Samples of the solution gave bubbles of gas with HNO_3 but no precipitate with $AgNO_3$. The anion present is

(A) Cl^{-1}

(B) NO_3^{-1}

(C) SO_4^{-2}

(D) CO_3^{-2}

19. The concentration of ozone in the troposphere is 0.000003% (v/v). What is this concentration in parts per million.

(A) 0.0003

(B) 0.03

(C) 0.003

(D) 0.000003

20. Which of the following is an isomer of 1,4 dichloro-4-fluoro-2-butene?

(A) 1 – bromopropane

(B) 1,2 – dichloro-2-fluoropropane

(C) 1,1 –dichloro-3-fluoro-2-butane

(D) 1,1 –dichloro-3-fluoro-2-butene

Name: Teacher:

SECTION I (continued)
Part B – 55 Marks
Attempt all questions 21-34
Allow about 1 hour and 35 minutes for this part
Show all relevant working in questions involving calculations

Question 21 (3 marks)

Explain the use of one named radioactive isotope in industry in terms of its properties.

Outcome criteria	Marks
Explains the industrial use of the named radioisotope with respect to two properties	3
Explains the industrial use of the named radioisotope with respect to one property	2
Identifies a radioisotope	1

Strontium-90 is used in thickness gauges. Strontium-90 has a low energy emission but a long half-life. Low energy emission is required so that the material can absorb the radiation and thereby indicated its thickness. Having a long half-life means that the radiation source does not have to be replaced frequently.

Strontium-90, cesium-137, cobalt-60 are used for monitoring the thickness of sheet materials such as paper, aluminium foil and steel products. Sodium-34 used for detecting leaks in water pipes (half-life is 15 hours).

Note:

Cobalt-60 is not used for "leaks" since its half-life is too long (5.3 years).
Industrial use and not medical use.

Name: Teacher:

Question 22 (3 marks)

Describe the conditions and chemistry associated with two different ways of forming ethanol.

Outcome criteria	Marks
Describes the conditions and chemistry associated with two different ways to form ethanol	3
Describes the conditions and chemistry associated with one way to form ethanol	2
Describes the conditions or chemistry associated with one way to form ethanol	1

$C_2H_4 + H_2O \rightarrow CH_3CH_2OH$ (requires dilute $H_2SO_4(aq)$ as a catalyst)

Or,

$C_6H_{12}O_6 \rightarrow 2\ CH_3CH_2OH + 2CO_2$ (requires yeast enzymes)

(1): reactants
(1): products
(1): conditions ("requires dilute $H_2SO_4(aq)$ as a catalyst"; "yeast enzymes and anaerobic conditions")

Question 23 (2 marks)

A 3.510 g sample of 1-propanol is combusted in heating a certain mass of water from 25^{o}C to 45^{o}C. 70.00 % of the heat released is absorbed by the water. The molar heat of combustion of 1-propanol is 2016 kJ mol^{-1}. What was the quantity of water heated?

Outcome criteria	Marks
(1): calculation of the amount of heat absorbed by the water in kJ (1): for using the relationship: $\Delta H = mC\Delta T$	2
One of the above given	1

3.510 g of 1-propanol = 0.05841 moles

0.05841 moles of 1-propanol liberates 117.75 kJ heat

70% of this heat is absorbed by water: 70% of 117.75 kJ = 82.43 kJ

$\Delta H = mC\Delta T$ $\quad$ 82.43 x 1000 J = m (4.18 J.K^{-1}.g^{-1})(20^{o}C)

m = 986.0 g water heated

Name: Teacher:

Question 24 (3 marks)

Assess the potential of ethanol as an alternative fuel.

Outcome criteria	Marks
Describes two advantages and two disadvantages of using ethanol as a fuel	3
Describes two advantages of ethanol as a fuel OR describes two disadvantages of ethanol as a fuel OR describes one advantage and one disadvantage of ethanol as a fuel	2
Describes one advantage and one disadvantage of ethanol as a fuel	1

Assess: make a judgement with respect to value, quality, outcomes results or size.

Ethanol has great potential as an alternative fuel.

Ethanol is a renewable resource while octane is a non-renewable resource. The production and use of ethanol is carbon dioxide neutral especially since it can be formed from processes such as fermentation of sugar cane which absorbs carbon dioxide from the air. Ethanol burns cleanly and does not release large amounts of pollutants such as CO and aromatic hydrocarbons such as benzopyrene into the atmosphere. As a petrol additive, ethanol enhances the combustion of petrol.

- Ethanol is a renewable resource
- Ethanol reduces dependence on oil
- Ethanol is cleaner burning
- Ethanol has lower greenhouse potential

However, ethanol production from biomass can require almost as much energy as what is obtainable from it when completely combusted. Also, being more oxygenated than petrol, it releases less energy per mole and per gram than petrol. Therefore, to obtain an equivalent amount of mileage from ethanol, more ethanol must be burnt. This requires a bigger fuel tank. The use of greater than 20% ethanol with petrol also necessitates car engine modification. There is also the problem of environmental pollution caused by the release of large quantities of fermentation liquor, soil degradation and soil erosion if vast quantities of agricultural land are devoted to crops for ethanol production. The use of ethanol depends upon the ambient temperature with ethanol cars harder to start in colder conditions than petrol (octane) cars.

- Ethanol produces less energy than petrol
- Ethanol production would require huge tracts of land which could impact on food production
- Ethanol is more costly to produce

Overall, if the production of ethanol can be made less energy demanding, such as the use of novel strains of bacteria for a more efficient fermentation, solar powered distillation units and the use of scraps and waste as raw materials, then ethanol has a very promising potential as a car fuel.

Name: Teacher:

Question 25 (2 marks)

A student was asked to perform a first-hand investigation to compare the reactivities of hexane and 1-hexene by observing their reactions with bromine water.

(a) Describe the reaction(s) observed by the student when the procedures were carried out in a darkened laboratory. (1 mark)

The hexene immediately decolourised the bromine water.

(b) Write an equation to show any addition reaction(s) that occurred. (1 mark)

$CH_3CH_2CH_2CH_2CH = CH_2 + Br_{2\ (aq)} \rightarrow CH_3CH_2CH_2CH_2CHBrCH_2Br$

Production of bromohydroxyhexane is also acceptable.

Name: Teacher:

Question 26 (7 Marks)

A standard solution of sodium carbonate (Na_2CO_3) was prepared by dissolving 5.46 g of the solid in water and making the volume up to 500.0 mL in a volumetric flask.

(a) Determine the concentration of the standard solution in mol L^{-1}. (1 mark)

Criteria	Mark
Calculates the concentration of sodium carbonate to 3 significant figures	1

Sample answer

Moles of sodium carbonate = 5.46/105.99 mol
= 0.0515 mol

Concentration of Na_2CO_3 c = n/v
= 0.0515/0.5000 mol L^{-1}
= 0.103 mol L^{-1} (to 3 significant figures)
= 1.03 x 10^{-1} mol L^{-1} (to 3 significant figures)

(b) Explain why sodium carbonate can be used to make a primary standard solution whereas sodium hydroxide is NOT appropriate for use as a primary standard.(2 marks)

Criteria	Marks
Explains why sodium carbonate is a suitable primary standard AND Explains why sodium hydroxide is NOT a suitable primary standard	2
Explains why sodium carbonate is a suitable primary standard OR Explains why sodium hydroxide is NOT a suitable primary standard	1

Sample answer

Sodium carbonate can be obtained pure, as a crystalline solid and has a relatively high molar mass. It can be weighed out accurately and transferred into a volumetric flask without absorbing water from the atmosphere or reacting with carbon dioxide.

Sodium hydroxide is not obtained as a pure crystalline solid and has a lower molar mass. When the solid pellets are exposed to air they absorb water and hence cannot be weighed out accurately. Sodium hydroxide also reacts with carbon dioxide and sulfur dioxide in the air, forming new compounds. The mass and chemical composition of the material changes as it is weighed, so sodium hydroxide is not suitable as a primary standard.

(c) Lillian analysed the acetic acid content of vinegar using a titration. She took 20 mL of the white vinegar and diluted it systematically to 100 mL.

(i) Lillian transferred 25.00 mL of the diluted vinegar to a conical flask. Name the piece of glassware she used for this procedure. (1mark)

Name: Teacher:

Criteria	Mark
Pipette	1

(ii) The diluted vinegar was titrated with 0.105 mol/L potassium hydroxide solution and the end point was reached with an average titre of 31.8 mL of the base. Identify from the following table suitable indicators for Kylie's titration and calculate the concentration of the acetic acid in the diluted vinegar. (3 marks)

Indicator	pH range
meta-cresol purple	1.2–2.8
bromophenol blue	3.0–4.6
congo red	3.0–5.0
bromophenol red	5.2–6.8
neutral red	6.8–8.0
thymol blue	8.0–9.6

Criteria	Marks
Correct indicator and correct concentration with units	3
Correct indicator and correct concentration with no units OR wrong indicator but correct concentration with units	2
Correct indicator OR correct concentration(Units not needed for I mark)	1

This is a weak-acid–strong-base titration and the equivalence point occurs between pH 8 and 9. The only suitable indicator is thymol blue.

$KOH + CH_3COOH \rightarrow KCH_3COO + H_2O(l)$

$n(KOH) = cV = (0.105)(31.8 \times 10^{-3})$

$= 3.339 \times 10^{-3}$ mol

$= n(CH_3COOH)$

$c(CH_3COOH) = n / V$

$= 3.339 \times 10^{-3} / 25.00 \times 10^{-3}$

$= 0.134$ mol/L

Name: Teacher:

Question 27

The oxides of the elements in the third period of the Periodic Table demonstrate a trend in acid-base properties.

Identify ONE element from this period which forms an oxide which is described as amphoteric. Write the formula for the oxide of this element and explain why it is classified in this way.

Criteria	Marks
Identifies the element and writes the formula for an amphoteric oxide AND explains why the oxide is described as amphoteric	2
Identifies the element and writes the formula for an amphoteric oxide OR Explains why the oxide is described as amphoteric	1

Sample answer

Aluminium forms an amphoteric oxide, Al_2O_3. It is classified as amphoteric because it can react with (neutralise) BOTH acids (like hydrochloric) and alkalis (like sodium hydroxide) to form salts and water.

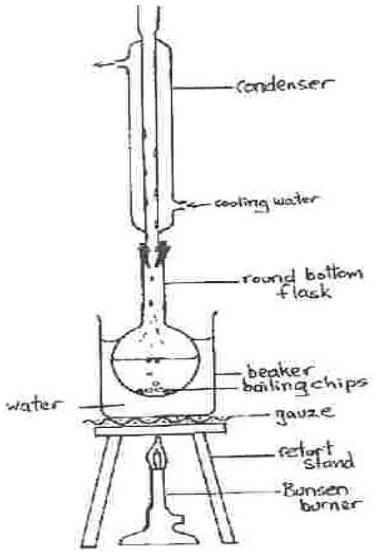
Question 28 (4 marks) **Marks**

A student prepared an ester in the school laboratory by heating formic acid and propanol with a suitable catalyst under reflux. **2**

(a) Draw a labelled diagram of the apparatus used for the reflux stage of this experiment.

Criteria	Marks
• Draws a correctly labelled scientific diagram of reflux apparatus	2
• Draws a partially correct diagram OR partially labelled scientific diagram	1

Name: Teacher:



(b) Justify TWO reasons for the use of heating under reflux during this experiment. **2**

Criteria	Marks
• Justifies 2 reasons for heating under reflux	2
• Justifies 1 reason for heating under reflux	1

The esterification process involves heating of flammable liquids, which could cause a fire if they came in contact with a naked flame. The use of the reflux condenser prevents the escape of volatile flammable liquids.

The ester has a low boiling point (volatile) and would evaporate from an open flask. Reflux conditions are needed to retain the prepared product.

Esterification is an endothermic equilibrium reaction. Heating is required to drive the equilibrium to the right to produce the optimal yield of ester.

Question 29 (6 marks)
The table below shows the solubility of carbon dioxide in water at various temperatures.

Temperature (° C)	Solubility (g of CO_2 per 100 g water)
0	0.320
10	0.220
20	0.170
30	0.130
40	0.095

(a) Use the grid below to graph these results. **2**

(b) The dissolving of carbon dioxide in water involves an equilibrium reaction. Write an equation to represent this equilibrium.

Criteria	Marks
• Writes the equation for the equilibrium reaction (including reversible arrows)	1

Sample answer

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

(c) Use the data in the table (on the previous page) to explain whether the equation you have written in part (b) is endothermic or exothermic.

Criteria	Mark
• Correct explanation using data	1

Sample answer
Since the solubility of carbon dioxide per 100 g water decreases as temperature increases, the backward reaction in the equation in part (b) must be favoured as temperature increases. Hence by Le Chatelier's Principle, the backward reaction must be endothermic and the forward reaction exothermic.

(d) A test for carbon dioxide involves bubbling the gas through limewater.

$$Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$$

Calculate the mass of carbon dioxide gas needed to produce 0.25 g of calcium carbonate by this reaction.

Criteria	Mark
• Correct answer	1

Sample answer

Using the balanced equation, 1 mole of calcium carbonate is produced from 1mole of carbon dioxide.

The molar mass of $CaCO_3$ = 100 g

Hence 0.25 /100 mole $CaCO_3$ is produced from 0.25/100 = 0.0025 mole CO_2

= 0.0025 x 44 g CO_2

= 0.11 g CO_2

Question 30

(a)

Criteria	Marks
• All products correctly identified and all equations correct with correct states.	2
• All products correctly identified OR all equations correct. OR • Any one error	1

Sample answer

Step 1: Bubbles of **carbon dioxide** $2H^+(aq) + CO_3^{-2}(aq) \longrightarrow H_2O(l) + CO_2(g)$

Step 2: white precipitate of **barium sulphate** $Ba^{+2}(aq) + SO_4^{-2}(aq) \longrightarrow BaSO_4(s)$

Step 3: white precipitate of **silver chloride** $Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)$

(b)

Criteria	Marks
• Correct answer and all steps shown in correct order	2
• Incorrect answer but some correct steps OR Any one error	1

Sample answer

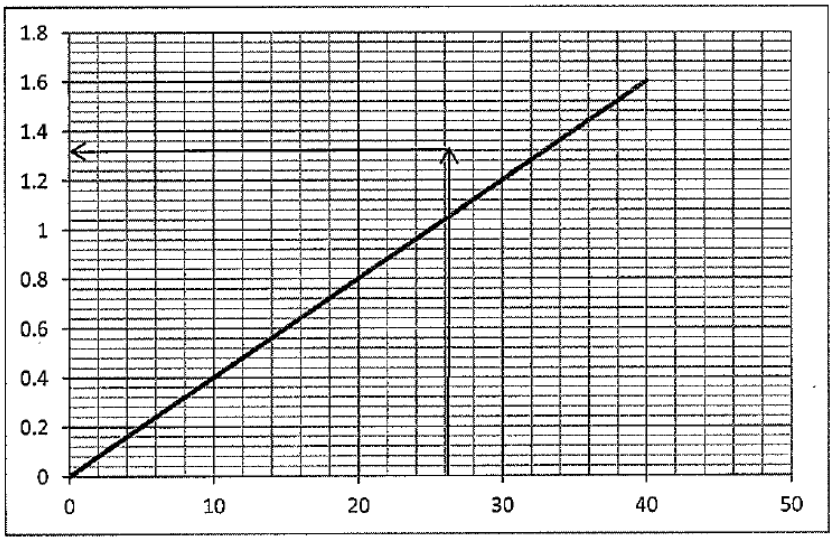
$M(BaSO4) = 233.37$ g/mol
$n = m/M = 3.325/233.37 = 0.01425$ mol
$n(SO4) = n(BaSO4) = 0.01425$ mol
$m(SO4) = nM(SO4) = (0.01425)(96.07) = 1.369$ g

% SO4 in fertiliser = $1.369/3.150 \times 100/1 = 43.5\%$

Name: Teacher:

Question 31 (a)

Criteria	Marks
• Correct answer AND CORRECTLY referenced on given graph AND correct conversion in gL-1	2
• Incorrect answer OR incorrect range OR NOT referenced from graph	1



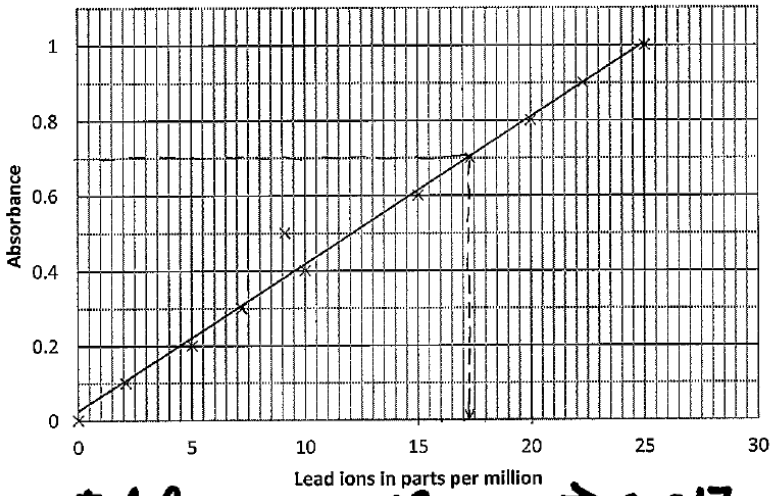
Sample answer

33ppm= 33mgL^{-1}=33/1000=0.033gL^{-1} accepted range= 0.032-0.034gL^{-1}

Name: Teacher:

Question 31 (6 marks)

A scientist decided to measure the concentration of lead (Pb) in the soil around an old paint factory site. He used the calibration graph to determine the concentration of lead (II) ions in a soil sample that gave an absorbance reading of 0.7.



Accepted Range 17–18 ppm ⇒ 0.017 – 0.018 gL^{-1}

(a) Express your answer in grams per litre. (1mark)

17.2 ppm = 17.2 mgL^{-1} = 17.2/1000 gL^{-1} = 0.0172 gL^{-1}

(b)

Criteria	Marks
• **Identifies that AAS is a sensitive technique** that allows -detection of trace elements like Pb in very low concentration **ppm or ppb.** -AAS can be used to analyse and measure the concentration of trace elements in a complex mixture with great accuracy. -AAS allows multiple replications, large sample numbers and higher accuracy. -AAS is **quicker** than non instrumental analytical methods such as titration. • **At least one Limitation** -More Expensive method -AAS data on heavy metals are limited by **varying sensitivities** and detection limits for each metal. • **Provides at least 3 examples of AAS used** in monitering levels of lead in substances used in society. -in paints/pigments -additive in petrol -soil samples -drinking water • **Identifies the harmful effect of lead** -Lead- Heavy and toxic metal. A severe neurotoxin, causes neurological disorders in children • **Provides at least two examples of environmental protection** -AAS helps in monitering lead - in soil, -waterways -atmosphere. • **Concludes by a valuable judgement**	5
• Any 4 of the above and valuable judgement	4
• Any 3 of the above and valuable judgement	3
• Any 3 of the above No judgement	2
• Any 2 of the above No judgement	1

Q32a.

Marking Guidelines	Marks
• Correctly names the compound.	**1**

2-chloro-1,1,1,2,2-pentafluoroethane.

Q32.b.

Marking Guidelines	Marks
• Outlines how the compound in a(i) can destroy ozone, including three correct chemical equations	**3**
• Outlines how the compound in a(i) can destroy ozone, OR • Includes 2 correct equations.	**2**
• Response includes one correct statement or equation.	**1**

The compound shown can destroy ozone because in the presence of UV light the C-Cl bond is broken, producing a chlorine free radical.

This Cl radical attacks ozone, and in a sequence of reactions shown below, is regenerated.

It is able to continue reacting with other ozone molecules, destroying thousands before it is removed from the atmosphere.

$CF_3CF_2Cl \rightarrow CF_3CF_2 + Cl$
$Cl + O_3 \rightarrow O_2 + ClO$
$ClO + O \rightarrow Cl + O_2$, and

thus the Cl atom is regenerated and continues to destroy O_3 molecules.

Name: Teacher:

Question 33

Marking Guidelines	Marks
• Explains in detail two reasons for the concern of the release of SO_2 and NO_2 • Judgement	**3**
• Explains in detail one reason for the concern of the release of SO2 and NO2	**2**
• Identifies one reason	**1**

Name: Teacher:

SECTION II
25 Marks
Allow about 45 minutes for this part
Answer the question in a writing booklet. Extra writing booklets are available
Show all relevant working in questions involving calculations

Question 33 - Industrial Chemistry (25 Marks)

(a) Identify one natural product that is not a fossil fuel, and discuss how the issues associated with shrinking reserves have been, or are being, addressed. **(3)**

(b) Gaseous hydrogen bromide partially decomposes to form hydrogen and bromine according to the equation:

$$2HBr\ (g) \qquad H_2\ (g) + Br_2\ (g)$$

At 450K, the equilibrium constant for the decomposition reaction is 0.0575.

Some hydrogen bromide gas was placed in an evacuated 3.00 L vessel and heated to 450K. When the system had reached equilibrium, the equilibrium concentration of hydrogen was found to be 9.50 x 10-4 mol L-1.

(i) Write the equilibrium constant expression for the decomposition reaction. **(1)**

(ii) Calculate the concentration of gaseous bromine in the equilibrium mixture at 450K. **(1)**

(iii) Calculate the concentration of gaseous hydrogen bromide in the equilibrium mixture at 450K. **(2)**

(iv) Explain the effect on this equilibrium of addition of a suitable catalyst to the reaction vessel. **(2)**

(c) (i) Identify a range of fats and oils used for soap making. **(2)**

(ii) Compare and contrast the conditions under which saponification can be performed in the school laboratory with the industrial preparation. **(3)**

(d) (i) Outline the cleaning action of soap, and include a labelled diagram of a micelle in your answer. **(3)**

(ii) Account for a use of an emulsion in terms of its properties. **(2)**

(iii) Synthetic detergents have been developed over the past 60 years.

Compare anionic, cationic and non-ionic synthetic detergents in terms of their use and chemical composition and the impact that these detergents have had on the environment. **(6)**

Name: Teacher:

Answers to Industrial Chemistry

(a)

Marking criteria	Marks

• Identifies a non-fossil fuel natural resource. AND • Identifies an issue associated with declining reserves. AND • Outlines how the issue has been/is being addressed	3
Identifies a non-fossil fuel natural resource. AND • Identifies an issue associated with declining reserves, or outlines how this issue has been/is being addressed	2
• Identifies a non-fossil fuel natural resource	1

Sample Answer

A non-fossil fuel resource is guano, used for centuries as a natural fertiliser because of its high nitrogen content. The use of fertiliser has increased enormously since the industrial revolution and the associated increase in food production and population growth. This has led to shrinking reserves of natural fertiliser, such as guano, to the point where chemical industry now supplies the vast majority of the fertiliser used in modern farming. Without this industrial supply, it would have been impossible to produce sufficient food to feed increasing populations, leading to more widespread starvation and famine.

(b) (i)

Criteria	Mark
• Correct answer	1

Sample answer

$$K = \frac{[H_2(g)]\ [Br_2(g)]}{[HBr(g)]^2}$$

(ii)

Criteria	Mark
• Correct answer	1

Sample answer

The concentration of bromine, $[Br_2(g)] = [H_2(g)] = 9.50 \times 10^{-4}$ mol L^{-1}

(iii)

Criteria	Marks

• Correct answer with units	2
• Correct value without units OR Correct moles for HBr	1

Sample answer

$K = \dfrac{[H_2(g)]\,[Br_2(g)]}{[HBr(g)]^2} = \dfrac{(9.50 \times 10^{-4})\,(9.50 \times 10^{-4})}{[HBr(g)]^2} = 0.0575$

Hence $[HBr(g)]^2 = \dfrac{(9.50 \times 10^{-4})\,(9.50 \times 10^{-4})}{0.0575} = \dfrac{9.025 \times 10^{-7}}{0.0575} = 1.569 \times 10^{-5}$

$[HBr] = 3.96 \times 10^{-3}$ mol L^{-1}

(iv)

Criteria	Mark
• Correct answer and reason	2
• No reason	1

Sample answer

The use of a catalyst will not alter the equilibrium composition. It will only increase the rate of reaction to reach equilibrium.

(c) (i)

Marking criteria	marks
Identifies one fat and one oil	2
Identifies one fat OR oil	1

Sample Answer
Tallow, Coconut oil

(ii)

Marking criteria	marks
Three comparisons with linking words (similarity and difference)	3
Two comparisons with at least one linking word(can be 2 similarities or 2 differences)	2
One comparison(no linking word)	1

Sample answer

Similarities	• Fats and oils are mixed with concentrated alkali and heated. • Concentrated brine is used to separate the soap from the aqueous phase. • The crude soap is washed.
Differences	• A blend of fats and oils is used in industry rather than one fat or oil used in the laboratory. • High-pressure steam is used to heat and stir the mixture in industry; a glass rod and a hotplate are used in the laboratory. • The glycerol is removed and purified in industry; in the laboratory, some glycerol remains in the soap. • In industry, settling of the soap occurs over several days; in the laboratory the soap is relatively crude and collected rapidly. • In industry, some old soap and salt is left in the kettle to emulsify the new reactants for the next batch; in the laboratory, methylated spirits is added to help emulsification. • No fragrances or colours were added to the soap produced in the laboratory.

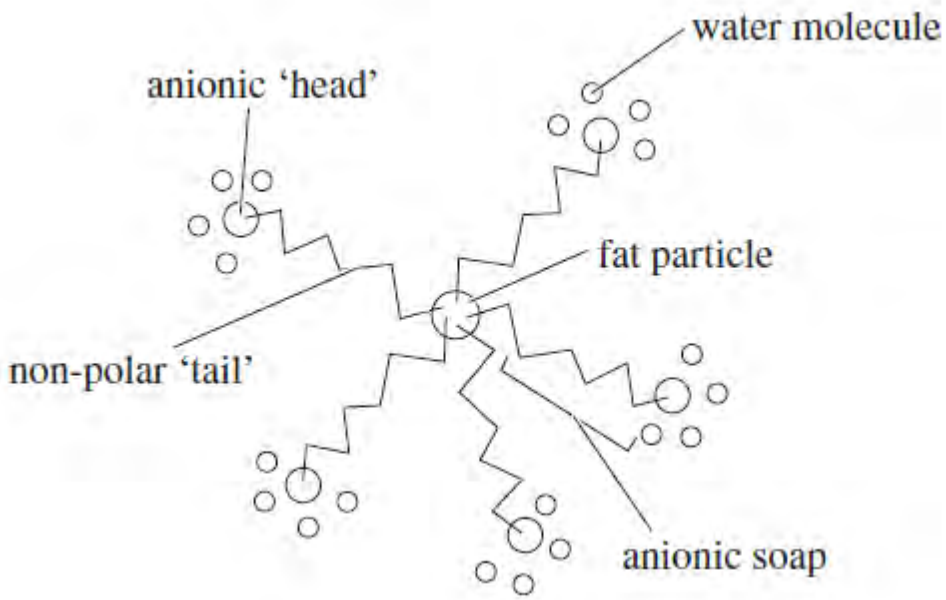
(d)
(i)

Marking criteria	marks
Explains the cleaning action of soap referring to the composition of soaps, the nature of fatty acid anions, the interaction of oils, anion and water, soap as surfactant and includes a labelled diagram of a micelle	3
Outlines the cleaning action of soap, and includes a labelled diagram of a micelle. OR • Explains the cleaning action of soap referring to the composition of soaps, the nature of fatty acid anions and the interaction of oils, anion and water	2
Draws a micelle. OR • Identifies one correct aspect of the cleaning action of soap	1

Name: Teacher:

Sample Answer

Soaps are typically the sodium salts of fatty acid anions, and the anionic component contains an hydrophilic (anionic) 'head' and an hydrophobic (non-polar) hydrocarbon 'tail'. When mixed with water and oil, soap acts as a surfactant and agitation of the mixture allows an emulsion to form. The hydrophobic tails dissolve in the fat particles, while the hydrophilic heads remain outside the fat particle, surrounded by water molecules. Each fat particle is surrounded by many fatty acid anions, forming a three-dimensional, spherical particle, known as a micelle. Micelles are soluble in water because of the layer of anionic, hydrophilic 'heads' and as a result, fats, oils and grease are able to be washed away.



(ii)

• Identifies a property of a named emulsion • States ONE use related to properties	**2**
• Identifies a property of a named emulsion	**1**

Sample answer
Cream, milk, cosmetic cleansers and mayonnaise are examples of oil-in-water emulsions. The fat in milk is stabilised in the water by an emulsifier called casein, a milk protein. Casein micelles also exist in the water phase. The fat colloids in ice-cream are stabilised by an emulsifier called glyceryl monostearate. In mayonnaise, the salad oil is stabilised in the vinegar by lecithin, which is present in egg yolk.
Butter, sunscreen, lipstick, cold cream and hand cream are examples of water-in-oil emulsions. These emulsions feel much greasier than oil-in-water emulsions due to the high proportion
of oil. Oil-in-water emulsions can be coloured with oil-soluble dyes due to their high oil content. Oil-in-water emulsions mix better with organic solvents, such as hexane or kerosene, than with water.

(iii)

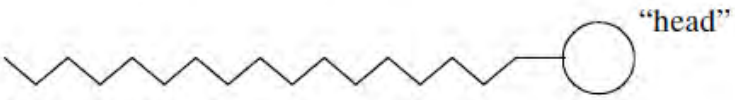
Name: Teacher:

• Demonstrates a thorough knowledge of the chemistry, uses and (historical) environmental impacts of anionic, cationic and non-ionic detergents • Shows how the THREE detergent types are different in terms of use and chemical composition • Provides a response that demonstrates coherence and logical progression of scientific principles and ideas	**5-6**
• Provides characteristics and features of anionic, cationic and non-ionic detergents • Clearly states how the THREE detergents differ in use and/or composition • Describes ONE impact that detergents have had on the environment	**4**
• Provides characteristics and features of TWO of the detergents • Describes ONE environmental issue caused by detergents	**2-3**
• Outlines detergents OR • Outlines an environmental issue related to detergents OR • Identifies a particular structure (draws a structure) and identifies correctly as anionic, cationic or non-ionic	**1**

Name: Teacher:

Sample answer:

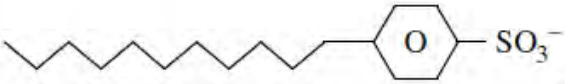
Synthetic detergents have been developed to replace soap. Synthetic detergents are synthesised
from the products of petroleum refining, unlike soaps that are derived from natural oils.
The three classes of synthetic detergents differ in some respects and are similar in others
All the detergents have a general structure as shown below



hydrophobic hydrocarbon

The hydrocarbon tail is more or less the same in each detergent. The "head" group changes the nature of the detergent.

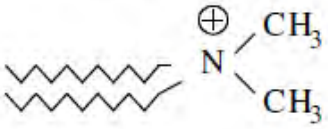
Anionic detergents have a negatively charged head group such as:



hydrophobic hydrocarbon alkyl sulfates

They foam strongly and are the most common form of synthetic detergent. They lather in hard water and are used in wide range of products such as laundry powders, shampoos, liquid soap and dish-washing powder because of the ability to remove grease and dirt.

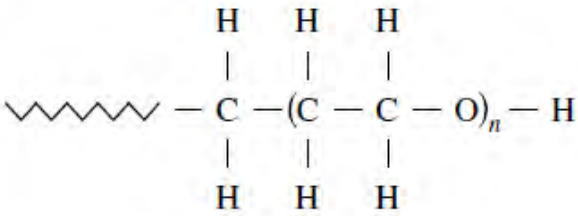
Cationic detergents have a positively charged head group.

eg 

quarternary ammoniun compounds

The cationic head binds strongly to negatively charged particles, meaning it attaches to surfaces "tail out". This makes them suitable for use as fabric softeners and hair conditioners. They are not used as "soaps" because they have a greasy feel. Other types are used as disinfectants and antiseptics because they disrupt bacterial membranes.

Non-ionic detergents have a non-charged head group.



polar ethoxylate group

The polar group improves the ability of non-polar and polar groups to adhere to each other.

They are low foaming and are often mixed with other detergents to reduce foaming such as in front loading washing machines and dishwashing powders.

The impact of these detergents on the environment has reduced over time. The initial impact wa high because they were not biodegradable and persisted in the environment. This lead to natural water bodies becoming choked with foam. This problem was solved by reducing chain branching in the non-polar tail.

The use of phosphate as a builder improves performance in hard water and also leads to eutrophications and algal blooms because phosphate increases nutrient loads of water. Phosphate levels are being reduced in synthetic detergents and replaced with other substances which remove Ca and Mg ions and therefore this impact is reducing.

Cationic detergents can also decrease the efficiency of sewage treatment because of their antibacterial nature, but since their use is generally low in most cases this impact is minimal.