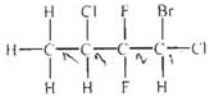
Section I

75 marks

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

1. Consider the structural formula shown below:



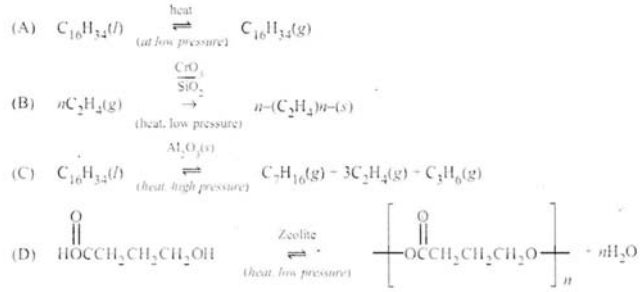
Which of the following is the systematic name for this compound?

A) 2,4-dichloro-4-bromo-3,3-difluorobutane
B) 4-bromo-2,3-dichloro- 3,3-difluorobutane
C) 1,3-dichloro-1-bromo-2,2-diflouorobutane
D) 1-bromo-1,3-dichloro-2,2-difluorobutane

2. Which of the following pairs of reactants would undergo a reaction to produce 2-chlorobutane in the absence of UV light?

A) Chlorine and 2-butene
B) Chlorine and butane
C) Hydrogen chloride and 2-butene
D) Hydrogen chloride and butane

3. Which equation best represents condensation polymerisation?



4. A sample of iron wire is dissolved in dilute H_2SO_4.

$Fe(s) + 2H^+ \rightarrow Fe^{2+} + H_2(g)$ (reaction 1)

Chlorine is then passed into the remaining solution:
$2Fe^{2+} + Cl_2(g) \rightarrow 2Fe^{3+} + 2Cl^-$ (reaction 2)

Which statement best describes the reaction shown above?

A) Fe is oxidised in reaction 1 forming Fe^{2+}, which then oxidised in reaction 2
B) Fe is reduced in reaction 1 forming Fe^{2+}, which then oxidised in reaction 2
C) Fe is reduced in reaction 1 forming Fe^{2+}, which then reduced in reaction 2
D) F e is oxidised in reaction 1 forming Fe^{2+}, which then reduced in reaction 2

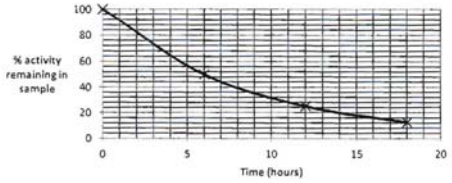
5. The equation below shows the bombardment of U-235 with a neutron initiating a fission reaction.

$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{147}Ba + X + 3n$

Which of the following correctly identifies X?

A) At-85
B) Kr-86
C) Ra-88
D) Th-90

6. The half-life of a radioisotope is the time taken for the activity of the radioisotope to decrease by one half.
The graph below shows how the % activity for a radioisotope changes over time.



Based on the graph above, which of the following could be a potential use for the radioisotope?

A) Determining the age of fossils
B) Treating a cancerous brain tumour
C) Detecting smoke particles in a home smoke detector
D) Diagnosing a problem with blood flow through the heart

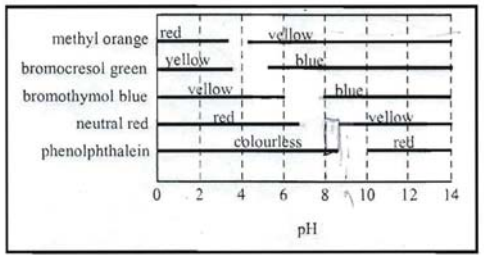
7. Lemon juice has a pH of about 2, whilst tomato juice has a pH of about 4.

Which statement correctly compares the hydrogen ion concentration of tomato juice with that of lemon juice?

A) The hydrogen ion concentration of tomato juice is greater, by a factor of 2.
B) The hydrogen ion concentration of tomato juice is greater, by a factor of 100.
C) The hydrogen ion concentration of tomato juice is less, by a factor of 2.
D) The hydrogen ion concentration of tomato juice is less, by a factor of 100.

8. A student determined the pH of a soil sample using indicators and achieved the following results:

Indicator	Colour
Methyl orange	yellow
Bromocresol green	blue
Bromothymol blue	blue
Neutral red	orange
Phenolphthalein	colourless



What value of pH corresponds to the student's results for the soil sample?

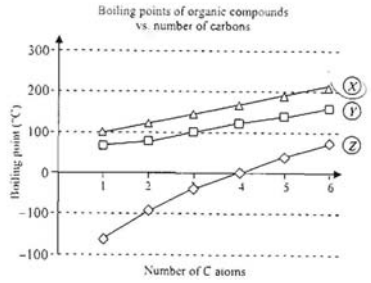
A) 6
B) 7
C) 8
D) 9

9. What volume of hydrogen gas, at 25°C and 100kPa, is produced by the reaction of 1.0g of magnesium with excess hydrochloric acid?

A) 0.5L
B) 1.0L
C) 25L
D) 50L

Student No. .....

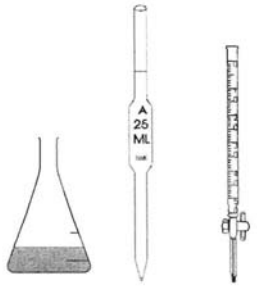
10. The graph below represents the boiling points of some straight chain alkanols, alkanes and alkanoic acids, plotted against the number of carbon atoms.



Which of the following correctly identifies X, Y and Z?

	X	Y	Z
A)	Alkanols	Alkanoic acids	Alkanes
B)	Alkanoic acids	Alkanols	Alkanes
C)	Alkanols	Alkanes	Alkanoic acids
D)	Alkanes	Alkanoic acids	Alkanols

11. Which of the following pieces of equipment may have water left in before it is used?



A) Y only
B) X and Y
C) X only
D) Y and Z

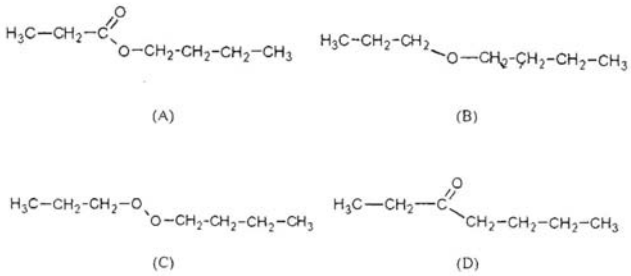
12. A minor buffering system in blood involves phosphoric acid (H_3PO_4) and dihydrogen phosphate ($H_2PO_4^-$).

$$H_3PO_4(aq) + H_2O(l) \rightleftharpoons H_2PO_4^-(aq) + H_3O^+(aq)$$

Which of the above species is amphiprotic?

A) H_2O and $H_2PO_4^-$
B) H_3PO_4 and H_2O
C) H_2O and H_3O^+
D) H_3PO_4 and $H_2PO_4^-$

13. A student mixes 1-butanol with propanoic acid in an esterification reaction. Which of the following shows the structure of the organic product?



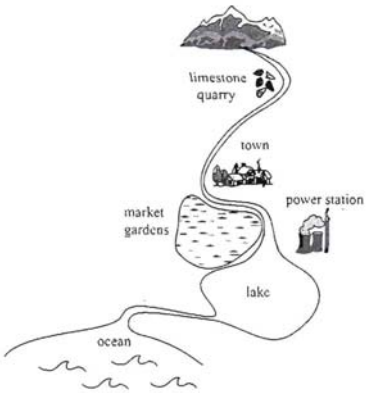
14. The molecules O_2 and O_3 are :

A) Allotropes
B) Compounds
C) Diatomic
D) Isotopes

15. Which of the following involves the formation of a coordinate bond?

A) $H_2 + \frac{1}{2}O_2 \rightarrow H_2O$
B) $NH_3 + HCl \rightarrow NH_4Cl$
C) $NaOH + HCl \rightarrow NaCl + H_2O$
D) $C_6H_{12}O_6 \rightarrow 2CH_3CH_2OH + 2CO_2$

16. Tests reveal that the water in the lake shown in the diagram below is 'hard' water.



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

A) Town
B) Power station
C) Limestone quarry
D) Market gardens

17. A solid sample was known to contain two calcium salts. In order to determine the anions present, some tests were done on the solid, producing the following results.

Test done	Results obtained
Observation of colour	White
Addition of water to solid	Solid partially dissolved
Addition of barium chloride to solution	No precipitate
Addition of silver nitrate to solution	White precipitate
Addition of HCl(aq) to solid	Gas bubbles observed

Which two ions were present in the sample?

A) CO_3^{2-} and Cl^-
B) CO_3^{2-} and PO_4^{3-}
C) PO_4^{3-} and SO_4^{2-}
D) SO_4^{2-} and Cl^-

18. A drop of dilute NaOH solution was added to a small sample of an unknown solution. A pale blue precipitate was formed. Dilute ammonia solution dissolved this precipitate forming a deep blue solution.
What is the cation in the original solution?

A) Barium (II) ion
B) Copper (II) ion
C) Iron (III) ion
D) Lead (II) ion

19. A 2.68g sample of lawn fertiliser was analysed for its sulphate content. After filtration and drying, 2.33g of barium sulphate was recovered. What is the % w/w of sulphate in the lawn fertiliser?

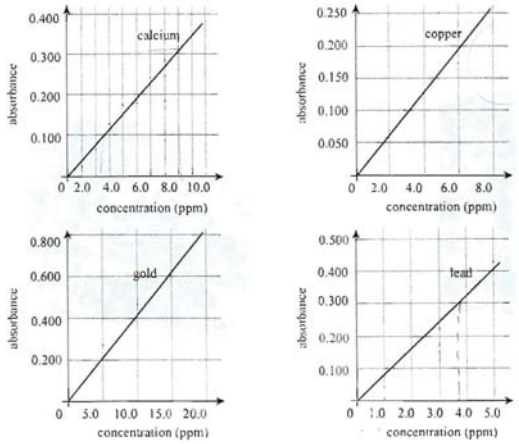
A) 18%
B) 36%
C) 41%
D) 88%

Student No. .....

20. The wavelength recommended for some elements, whose concentrations were to be measured using atomic absorption spectroscopy, are shown in the table below.

Element	Recommended wavelength (nm)
Calcium	422.7
Copper	324.8
Gold	242.8
Lead	217.0

Absorption measurements for standard solutions of these elements at the recommended wavelengths produced the following calibration curves:



The solid waste from a gold mine was analysed and the following results were obtained:

Absorbance	Wavelength (nm)
0.30	217.0
0.20	324.8
0.10	422.7
0.05	242.8

The element present in the highest concentration is

A) calcium
B) copper
C) gold
D) lead

Section I (continued)

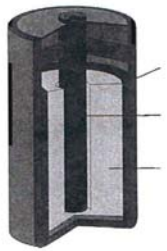
Part B - 55 marks
Attempt Questions 21-30

Allow about 1 hour 40 minutes for this part

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

Question 21. (4 marks)

As part of your studies of electrochemistry, you studied the chemical composition and features of either a dry cell or a lead-acid battery.

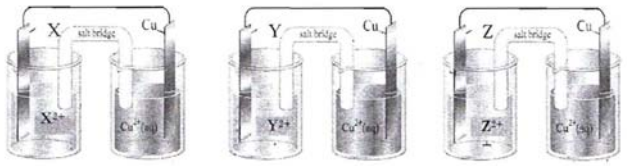


(a) Identify the electrolyte used in the cell you studied. (1)

(b) Explain how the battery you studied has impacted on society and the environment. (3)

Question 22. (4 marks)

Half-cells made from three metals (X, Y and Z) and their solutions were coupled with a copper half-cell under standard conditions, as shown in the diagram below.



The voltage produced and the polarity of the copper electrode, were recorded in a table below.

Metal	Cell voltage produced by coupling metal half-cell with Cu half-cell	Polarity of copper
X	0.31	+ve
Y	1.14	-ve
Z	0.42	-ve

(a) Outline the function of the salt bridge in the cells above. (1)

(b) Using the data provided, rank the metals (X,Y, Z and Cu), in increasing order of reactivity. (1)

(c) Explain how you arrived at your answer. (2)

Question 23. (7 marks)

Ethanol can be produced from two different raw materials.

These processes can be represented in the diagram below.

Process 1 CELLULOSE ⟶ ETHANOL

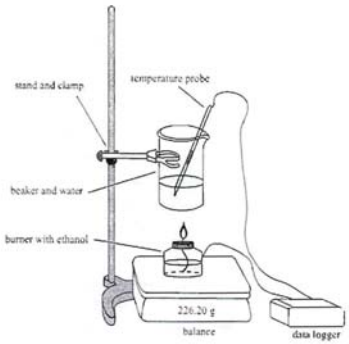
Process 2 CRUDE OIL ⟶ ETHANOL

(a) Outline the physical and chemical changes that would occur in Process 2, including a balanced chemical equation with your answer. (3)

(b) Discuss the benefits and limitations of producing ethanol from Process 1 compared to producing it from Process 2, including a relevant equation with your answer. (4)

Question 24. (4 marks)

A student performed a first -hand investigation to determine the molar heat of combustion of ethanol. A quantity of 30.0g of ethanol was placed into a spirit burner. The spirit burner was then placed onto an electronic balance. A temperature probe was placed into the beaker containing 250.0g of water and this was clamped above the spirit burner. The temperature probe and the electronic balance were connected to a data logger (as shown in the diagram).



The burner was ignited and the data logger recorded the results tabulated below.

Mass of burner and ethanol(g)	Temperature (°C)	Mass of ethanol burnt (g)	Temperature Change (°C)
226.20	23.4	0.00	0
225.70	28.3	0.50	4.9
225.45	38.4	0.75	15.0
224.95	43.4	1.25	20.0
224.55	48.4	1.65	25.0
224.20	53.4	2.00	30.0
224.00	54.5	2.20	31.1

Calculate the molar heat of combustion of ethanol using this data. (4)

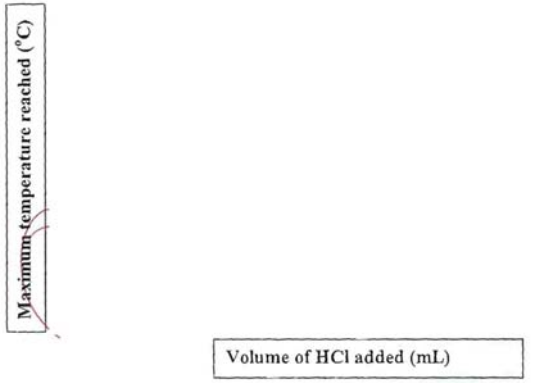
Question 25. (10 marks)

A student used temperature change during neutralization to calculate the concentration of hydrochloric acid. The method they used was:

1. 1L of 0.145M NaOH and 1L of HCl were allowed to sit at room temperature for 60 minutes
2. 25.0 mL of 0.145M NaOH were added to a polystyrene cup using a volumetric pipette.
3. The temperature of the NaOH solution was measured using a thermometer.
4. 10.0mL of HCl was added to the cup using a volumetric pipette.
5. The highest temperature reached was measured.
6. Steps 1 – 5 were repeated with 20, 30, 40, 50 and 60 mL of HCl.
   The results they obtained are shown in the table below.

V (HCl) added versus T (°C) when neutralizing 0.145M NaOH	
Volume of HCl added (mL)	**Maximum temperature reached (°C)**
0	21.0
10	28.0
20	35.0
30	35.0
40	32.5
50	30.0
60	27.5

(a) ~~Use the grid below to~~ graph the data above. (2)



Question 25 continues on the next page

Question 25 (continued)

(b) Draw two straight lines through the points and extend them until they cross. (1)

(c) What volume of HCl was required to completely neutralize the NaOH? On your graph show how you obtained this value. (2)

(d) Calculate the concentration of the HCl. (3)

(e) Assess the validity of this experiment. (2)

Question 26. (6 marks)

A can of soda water contains carbon dioxide dissolved under pressure, forming carbonic acid.

(a) With the aid of a chemical equation, explain why carbonic acid is described as a weak acid. (1)

(b) Using Le Chatelier's Principle, outline the change in pH of the contents, after a can of soda water is opened. Justify your answer. (2)

(c) During the last century the concentration of carbon dioxide in the troposphere has increased from about 270ppm to 400ppm.

Describe the effect of this atmospheric change on the pH of a freshwater lake, and identify one problem which could result. (3)

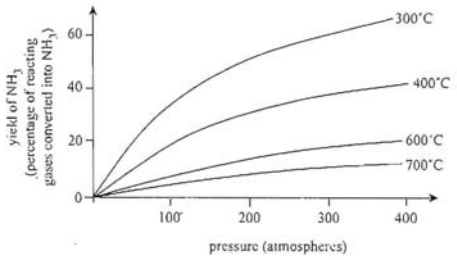
Question 27. (4 marks)

Hydrogen sulphide gas is formed when hydrochloric acid reacts with sodium sulphide. In an experiment, 0.15g of sodium sulphide was added to 25.0 mL of 0.10m HCl.

Calculate the maximum volume of hydrogen sulfide gas that could be produced by this reaction at 25°C and 100kPa.

Question 28. (5 marks)

The percentage of ammonia in the equilibrium mixtures resulting from the synthesis of ammonia from its elements is shown in the graph below.



(a) With reference to the graph above and a suitable balanced equation, explain the effects of temperature and pressure on the percentage yield of ammonia at equilibrium. (3)

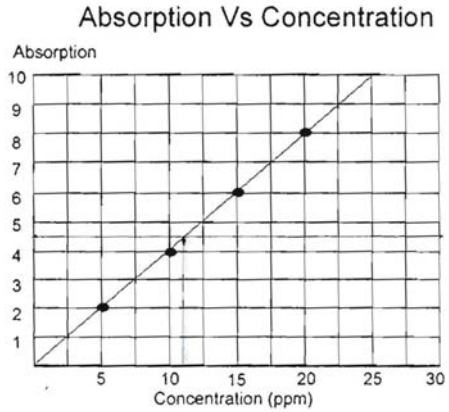
Question 28 continues on the next page

Question 28 (continued)

(b) Describe the effect of adding iron (III) oxide to this process. (2)

Question 29. (5 marks)

Oysters from an unknown source were suspected of having a high lead content. A 2.00g sample of oyster was tested for lead content using atomic absorption spectroscopy (AAS) and was found to have an absorbance of 4.5.



(a) Use the calibration graph above to determine the concentration of the lead in the sample. (1)

Question 29 continues on the next page

Question 29 (continued)

(b) The recommended limit of lead in oysters for human consumption is 3.00 ppm in every gram. Explain the significance of this result for human health. (2)

(c) Discuss the choice of AAS in measuring contaminants such as lead. (2)

Question 30. (6 marks)

Relatively recent human activity has reduced the concentration of ozone in the upper atmosphere, with serious consequences.

The molecules responsible for ozone depletion are CFCs such as CF_3CF_2Cl.

(a) Identify one source of CFCs. (1)

(b) Describe how a compound such as CF_3CF_2Cl can destroy ozone. Support your answer with equations. (3)

Question 30 continues on the next page

Question 29 (continued)

(c) Outline the consequences of ozone depletion in the upper atmosphere. (2)