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Student Number

Sydney Girls High School

2020

TRIAL
HSC
EXAMINATION

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A data sheet, formulae sheet and Periodic Table are provided at the back of this paper
- For questions in Section II, show all relevant working in questions involving calculations

Total Marks:
100

Section I – 20 marks (pages 2-10)

- Attempt Questions 1-20
- Allow about 35 minutes for this section

Section II – 80 marks (pages 13-31)

- Attempt Questions 21-34
- Allow about 2 hours and 25 minutes for this section

Section I

20 marks

Attempt Questions 1 - 20

Allow about 35 minutes for this part.

Use the multiple-choice answer sheet for Questions 1–20.

- 1** How is solubility used by Aboriginal and Torres Strait Islander peoples in the preparation of food sources, such as the fruits of cycads?
- A. The toxins in the ground-up fruits are soluble in running water.
 - B. The skins of the cycad fruits easily dissolve in water leaving essential nutrients.
 - C. Placing the cycad fruits in water removes hard to digest food products such as fibres.
 - D. The starch in the fruits of cycads is more soluble than the toxins found in these fruits.
- 2** What is the shape of the molecule formed between carbon atoms when a single bond is formed between them?
- A. Tetrahedral
 - B. Linear
 - C. Bent
 - D. Planar
- 3** Which of the following substances is amphoteric?
- A. NO_2^-
 - B. H_2PO_4^-
 - C. H_2SO_3
 - D. H_2CO_3

- 4 Three chemical formulas are shown below.

Compound A: $\text{CH}_3(\text{CH}_2)_{15}\text{COONa}$

Compound B: $\text{CH}_3(\text{CH}_2)_5\text{CONH}_2$

Compound C: $\text{CH}_3(\text{CH}_2)_5\text{COCH}_3$

What are the names of the chemical groups to which these compounds belong?

	<i>Compound A</i>	<i>Compound B</i>	<i>Compound C</i>
A.	Soap	Amine	Ketone
B.	Carboxylic acid	Amine	Aldehyde
C.	Soap	Amide	Ketone
D.	Ester	Amide	Aldehyde

- 5 The following table shows the colour changes and pH ranges of three indicators:

<i>Indicator</i>	<i>Colour change</i>	<i>pH range</i>
Bromophenol blue	Yellow to blue	3.0-4.5
Methyl red	Red to yellow	4.5-6.3
alizarin	Yellow to red	10.2-12.0

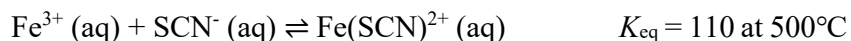
The indicators were used to test a liquid. The following table shows the final colours of the liquid.

<i>Indicator</i>	<i>Colour</i>
Bromophenol blue	Blue
Methyl red	Yellow
Alizarin	Yellow

Which one of the following substances was tested?

- A. Vinegar (pH 2.1)
- B. Distilled water (pH 7.0)
- C. Rain water (pH 5.2)
- D. Bleach (pH 12.1)

- 6 The equation for the iron (III) thiocyanate equilibrium is shown:



Which of the following is correct when this system is at equilibrium?

	<i>Forward reaction</i>	<i>Concentration of reactants and products</i>	<i>Molecule collisions</i>
A.	Faster than the reverse reaction	Equal	Still occurring
B.	Equals the reverse reaction rate	Not equal	Stopped
C.	Equals the reverse reaction rate	Equal	Still occurring
D.	Equals the reverse reaction rate	Not equal	Still occurring

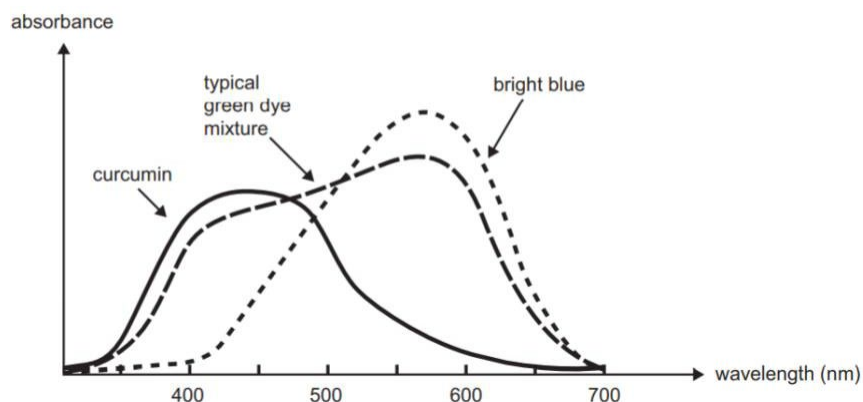
- 7 Which row of the table correctly matches the polymer with its structural feature and property?

	<i>Polymer</i>	<i>Structural feature</i>	<i>Property</i>
A.	Polystyrene	Branching	Opaque
B.	Nylon	Tightly packed molecules	Strong
C.	Low density polyethylene	Crystalline	Flexible
D.	High density polyethylene	Amorphous	Rigid

- 8 Which of the following would cause the pH of a solution to decrease by three?

- A. Diluting 10.0 mL of 0.01 M NaOH (aq) to 10.0 L
- B. Diluting 10.0 mL of 0.01 M NaOH (aq) to 40.0 mL
- C. Diluting 10.0 mL of 0.01 M HCl (aq) to 10.0 L
- D. Diluting 10.0 mL of 0.01 M HCl (aq) to 40.0 mL

- 9 1 litre of buffer solution is made by combining which two substances?
- A. 0.1 mol acetic acid and 1.0 mol sodium acetate
 - B. 0.1 mol hydrochloric acid and 0.1 mol sodium chloride
 - C. 0.2 mol sodium dihydrogen phosphate and 0.2 mol sodium hydrogen phosphate
 - D. 0.2 mol sodium hydrogen carbonate and 0.2 mol potassium hydrogen carbonate
- 10 How many chain isomers are there for C_6H_{14} ?
- A. 2
 - B. 3
 - C. 4
 - D. 5
- 11 A green dye used to colour tinned peas is made by mixing yellow chemical, curcumin, with another colouring agent called bright blue. The individual spectra of curcumin, bright blue and a typical green dye are represented below.

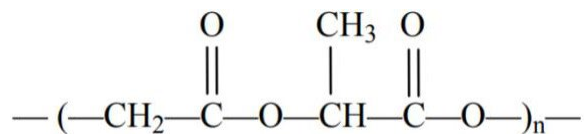


UV-visible spectroscopy is used to analyse the curcumin content of tinned peas.

Which wavelength would be best used for absorbance measurements to determine the curcumin content of the peas?

- A. 400 nm
- B. 440 nm
- C. 500 nm
- D. 575 nm

- 12 Cuts and wounds are often stitched using a biodegradable polymer with the formula



It is made from a condensation polymerisation reaction between lactic acid ($\text{HOCH}(\text{CH}_3)\text{COOH}$) and glycolic acid.

What is the formula of glycolic acid?

- A. $\text{HOCH}_2\text{CH}_2\text{OH}$
- B. HOCH_2COOH
- C. $\text{HOOCCH}_2\text{COOH}$
- D. $\text{HOOCCH}_2\text{CH}_2\text{OH}$
- 13 In which of the following alternatives are the four compounds listed in order of increasing boiling point?
- A. Pentanamide, pentanoic acid, pentanal, pent-1-ene
- B. Pent-1-ene, pentane, pentan-1-ol, pentan-1-amine
- C. Pentane, pent-1-ene, pentanoic acid, pentanamide
- D. Pent-1-ene, pentan-1-one, pentanamine, pentanoic acid
- 14 What is the concentration of hydroxide ions in a saturated solution of barium hydroxide at 25°C ?
- A. $1.60 \times 10^{-2} \text{ mol L}^{-1}$
- B. $3.19 \times 10^{-2} \text{ mol L}^{-1}$
- C. $3.99 \times 10^{-2} \text{ mol L}^{-1}$
- D. $7.99 \times 10^{-2} \text{ mol L}^{-1}$

- 15 The data below shows the acid dissociation constants for four acids.

<i>Acid</i>	<i>K_a</i>
Chlorous acid	1.1×10^{-2}
Hydrocyanic acid	6.2×10^{-10}
Hydrofluoric acid	6.6×10^{-4}
Lactic acid	1.4×10^{-4}

Which of the following statement is correct?

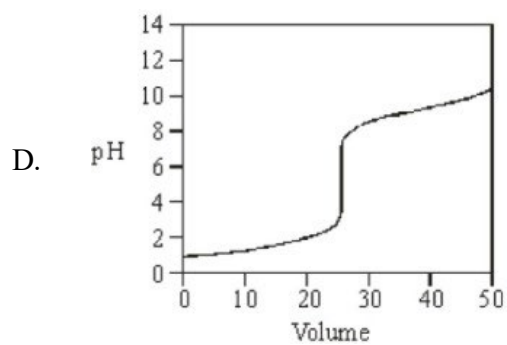
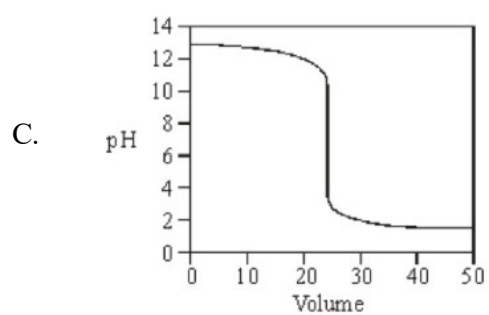
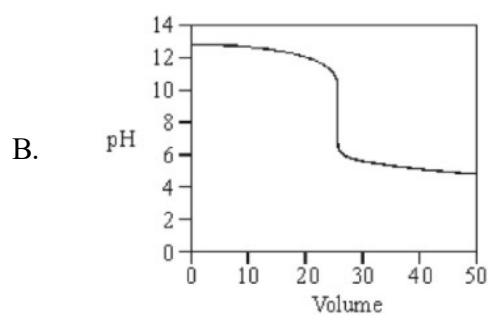
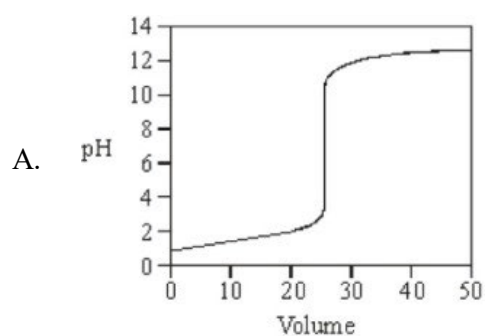
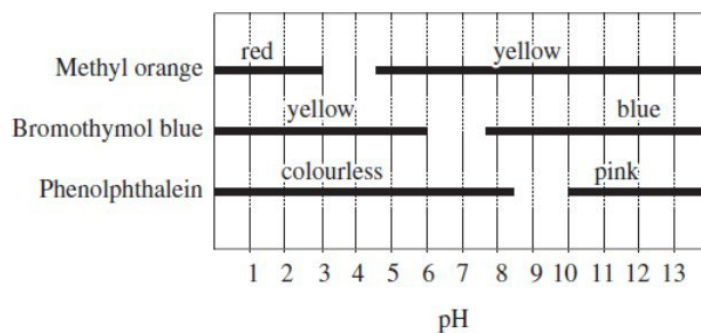
- A. The strongest acid is lactic acid
- B. The pK_a for the strongest acid is 3.2
- C. The acid which form the strongest conjugate base is chlorous acid
- D. The acid which produces the lowest concentration of hydronium ions in water is hydrocyanic acid

- 16 120 mL of 0.50 mol L⁻¹ sodium hydroxide was added to 80 mL of 0.50 mol L⁻¹ sulfuric acid. Both solutions were at a temperature of 22.5°C. After mixing, the final temperature was 24.1°C.

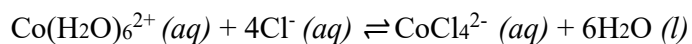
What is the enthalpy of neutralisation for this reaction?

- A. 31.35 kJ mol⁻¹
- B. - 22.29 kJ mol⁻¹
- C. 44.6 kJ mol⁻¹
- D. - 44.6 kJ mol⁻¹

- 17 For which titration would the use of methyl orange indicator introduce a significant error?

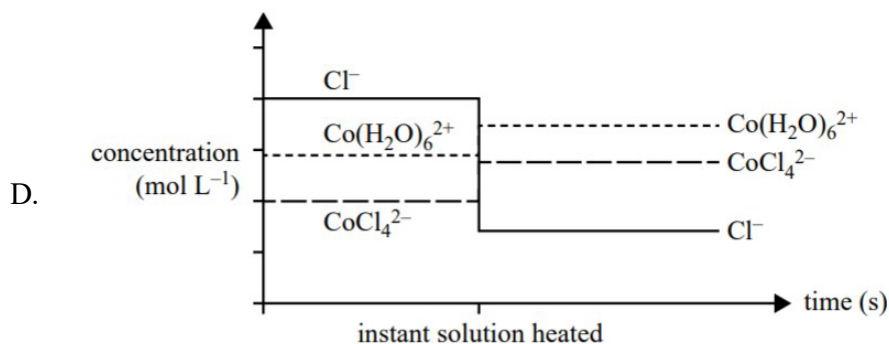
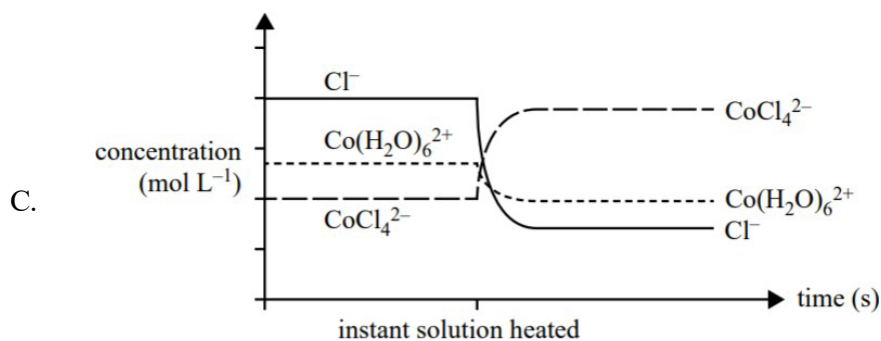
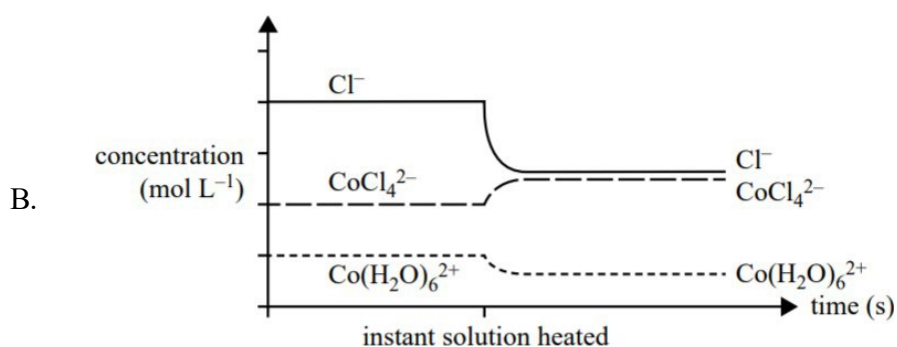
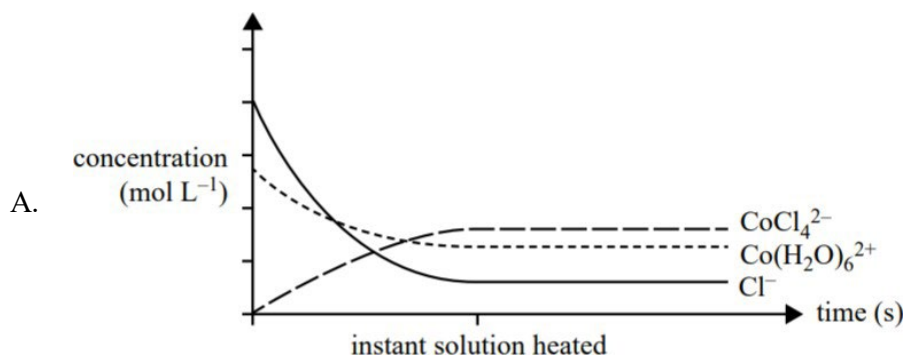


18 A solution contains an equilibrium mixture of pink $\text{Co}(\text{H}_2\text{O})_6^{2+}$ ions and blue CoCl_4^{2-} ions.

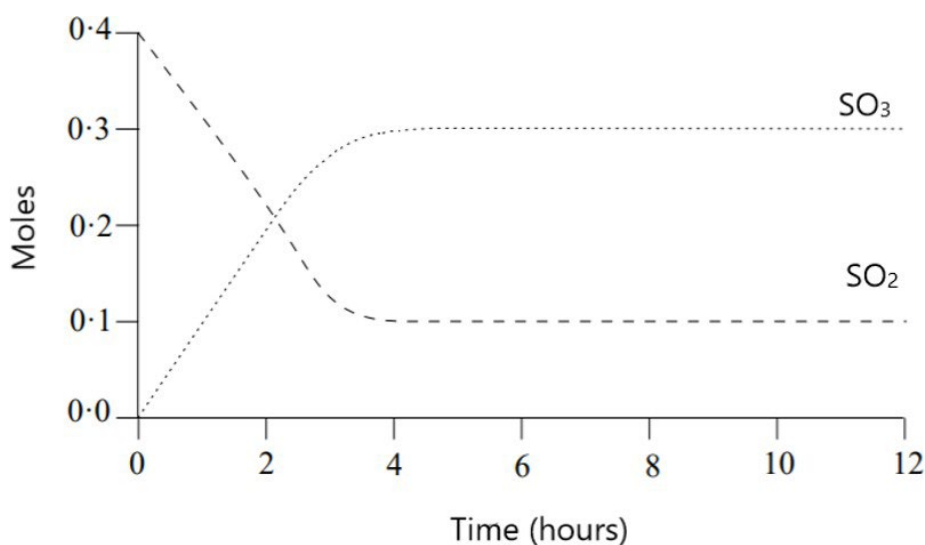


The system was heated, the colour changed from purple to blue.

Which one of the following graphs best represents this change?



- 19 At room temperature 0.4 moles of SO_2 and 0.2 moles of O_2 were introduced into a sealed 10 L vessel and allowed to come to equilibrium.



What is the equilibrium constant at time 6 hours?

- A. 18
B. 180
C. 600
D. 1800
- 20 A soluble fertiliser contains phosphorus in the form of phosphate ions. To determine the phosphate ion 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 phosphate ions in the solution were precipitated as $\text{Ba}_3(\text{PO}_4)_2$. The precipitate was filtered, washed with water and the mass was 0.0352 g.

What is the percentage of phosphate ions, by mass, in the fertiliser?

- A. 0.18%
B. 1.16%
C. 2.33%
D. 7.37 %

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Student Number

Chemistry

Section II Answer Booklet

80 marks

Attempt Questions 21-34

Allow about 2 hours and 25 minutes for this section

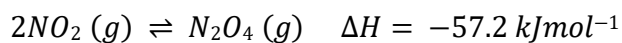
Instructions

- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of the response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

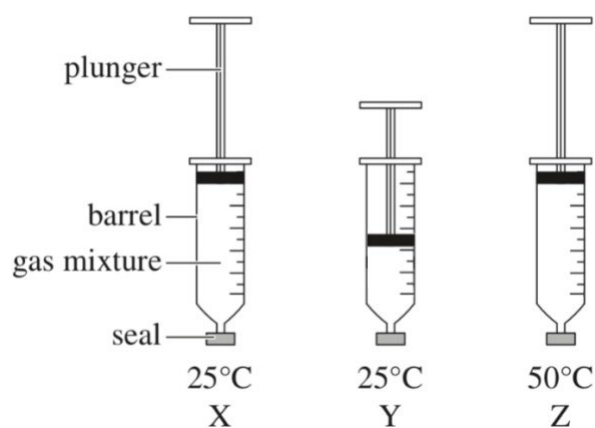
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Question 21 (8 marks)

Nitrogen dioxide is brown and dinitrogen tetroxide is colourless. They form an equilibrium mixture as shown in the following equation:



A sealed gas syringe can be used to investigate the properties of a fixed mass of gas. An equimolar mixture of nitrogen dioxide and dinitrogen tetroxide was set up as shown in X in the following diagram. The conditions were then varied as shown in Y and Z.



- a) Complete the table by describing the colour of the gas mixtures in X, Y and Z. Include any comparisons to the initial colour of X and justify your answers.

	Colour	Justification
X		
Y		
Z		

Question 21 continues on page 14

Question 21 (continued)

- b) Describe the effect of the varied conditions on the equilibrium constant in Y and Z to X.

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End of Question 21

Question 22 (4 marks)

Ethanol can be produced by the fermentation of glucose.

- (a) Identify and explain the experimental conditions required for the fermentation of glucose.

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- (b) Calculate the theoretical volume of carbon dioxide gas produced by the fermentation of 5.00 g of glucose at 25°C and 100 kPa.

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Question 23 (3 marks)

1 litre aqueous solutions of two different acids, HA and HB, are prepared with each solution containing 1.0×10^{-2} moles of the acid. Upon investigation, the pH of HA is 2.0 while the pH of solution HB is 4.2.

Explain what the results of the pH analysis indicates about the properties of each acid. Draw diagrams in the space below to model your explanation.

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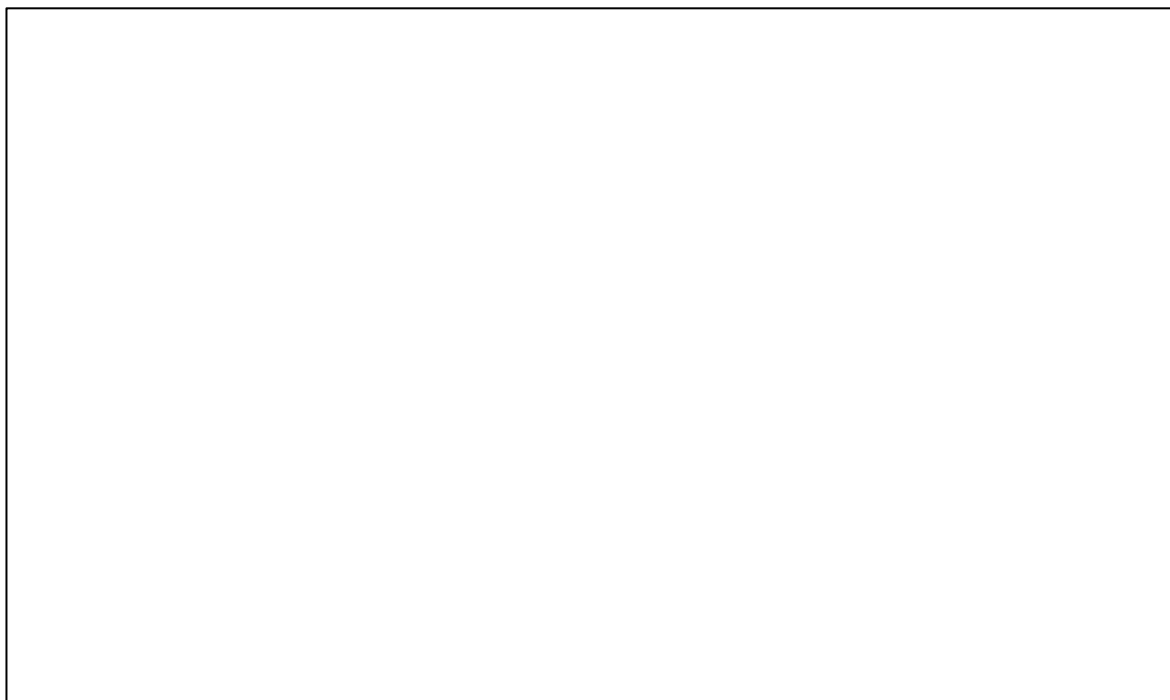
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Question 24 (6 marks)

A water sample taken from a lagoon has been sent to an environmental chemist. Fish, crustaceans and other aquatic life were found dead in the lagoon.

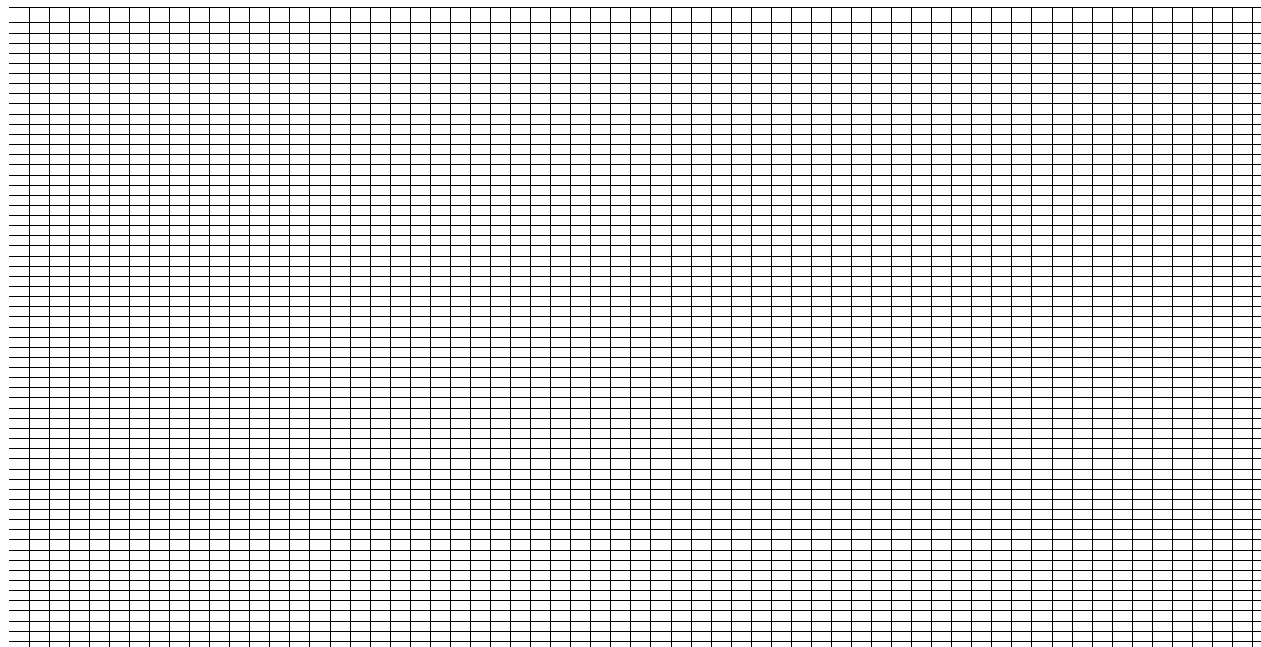
The chemist observed that the water sample had a faint blue appearance. The chemist tested for the presence of copper (II) ions which were found to be present.

She prepared a series of standard solutions of copper (II) sulfate and measured their absorbance using colourimetry. The results are shown below.

Solution	Blank	Standard 1	Standard 2	Standard 3	Standard 4	Standard 5
Concentration of CuSO_4 (mol L^{-1})	0.00	0.10	0.20	0.30	0.40	0.50
Absorbance	0.00	0.280	0.560	0.830	1.110	1.390

(a) Plot the data on the grid below.

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Question 24 continues on page 17

Question 24 (continued)

- (b) The lagoon water was then tested in the same way and its absorbance was found to be 0.506. A concentration of copper (II) ions from 0.05 – 2.0 ppm has been found to be toxic to various aquatic organisms.

Is it possible that copper (II) ion contamination is responsible for the death of aquatic organisms in the lagoon? Explain. **3**

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End of Question 24

Question 25 (3 marks)

A bottle of solution is missing its label. It contains one of the following: $\text{Ba}(\text{NO}_3)_2$, $\text{Fe}(\text{NO}_3)_2$, AgNO_3 or $\text{Ca}(\text{NO}_3)_2$

Describe a method that would confirm the identity of the solutions in the bottle. Include observed results and ionic equations in your answer.

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Question 26 (6 marks)

Cyclohex-1-ene and cyclohexane are colourless liquids at room temperature.

- (a) Outline a method that could be used in the school laboratory to distinguish between these liquids. Describe and explain the expected results, including any relevant chemical equations. **4**

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- (b) Organic reagents must be handled safely. Explain one safety procedure relevant to this investigation. **2**

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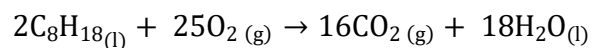
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Question 27 (4 marks)

The following data apply to the combustion reaction of octane.



	$\Delta H_f^\ominus$ (kJ mol ⁻¹)	$S^\ominus$ (J K ⁻¹ mol ⁻¹)
$\text{C}_8\text{H}_{18(l)}$	-250	361
$\text{O}_{2(g)}$	0	205
$\text{CO}_{2(g)}$	-393	214
$\text{H}_2\text{O}_{(l)}$	-285	189

By calculating Gibbs free energy explain why this reaction is considered a non-equilibrium system under standard conditions.

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Question 28 (7 marks)

The following table shows the solubility of three ionic compounds.

<i>Ionic compounds</i>	<i>Solubility at 25°C (g/100mL)</i>
Lead (II) nitrate	60
Magnesium chloride	54
Lead (II) chloride	1.6×10^{-3}

- (a) Explain the processes that occur when 15 g of lead (II) nitrate is added to water

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- (b) A student mixes 100 mL of $1.2 \times 10^{-3} \text{ mol L}^{-1}$ lead (II) nitrate solution with 150 mL of $3.0 \times 10^{-4} \text{ mol L}^{-1}$ magnesium chloride solution. Determine whether a precipitate will form.

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Question 29 (8 marks)

- (a) “When an acid reacts with a base, the salt solution formed is always neutral at 25°C.”

Evaluate this statement using a range of examples and relevant chemical equations. **5**

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Question 29 continues on page 23

- (b) Identify a substance which would be classified as either a Brønsted-Lowry acid or base but not as an acid or base by the Arrhenius theory. Explain your reasoning and include relevant chemical equations.

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End of Question 29

Question 30 (6 marks)

The calcium carbonate content of limestone was determined using the following procedure.

- A 8.00 g sample of limestone was dissolved in 85.0 mL of 0.950 mol L⁻¹ hydrochloric acid solution.
- The solution was heated to ensure that all the carbon dioxide was expelled then cooled.
- This mixture was titrated with 0.125 mol L⁻¹ standardised sodium hydroxide.
- The volume of standardised sodium solution used in the titration was 22.75 mL.

(a) Calculate the mass of calcium carbonate in the original limestone sample.

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Question 30 continues on page 25

(b) Explain why sodium hydroxide needs to be standardised before used in a titration.

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Question 31 (5 marks)

The table provides data regarding physical properties of alcohols.

<i>Alcohol</i>	<i>Molecular weight (g mol^{-1})</i>	<i>Boiling point ($^{\circ}\text{C}$)</i>	<i>Solubility ($\text{g}/100 \text{ mL}$ at 25°C)</i>
$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$	60.1	97.2	miscible
$\text{CH}_3\text{CHOHCH}_3$	60.1	82.3	miscible
$(\text{CH}_3)_3\text{COH}$	74.1	82.6	miscible
$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$	74.1	117.7	7.3
$\text{CH}_3\text{CH}_2\text{CHOHCH}_3$	74.1	99.5	2.9
$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$	88.2	138	2.2
$\text{CH}_3\text{CH}_2\text{CHOHCH}_2\text{CH}_3$	88.2	115.9	5.9

Explain the trends in boiling point and solubility shown in the table with increasing molecular weight.

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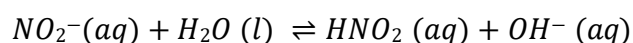
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Question 32 (5 marks)

The following reaction takes place when sodium nitrite is dissolved in water.

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Given that $K_w = K_a \times K_b$ and that the $\text{p}K_a$ of nitrous acid is 3.16 at 25°C, calculate the pH of a 0.24 mol L⁻¹ solution of sodium nitrite.

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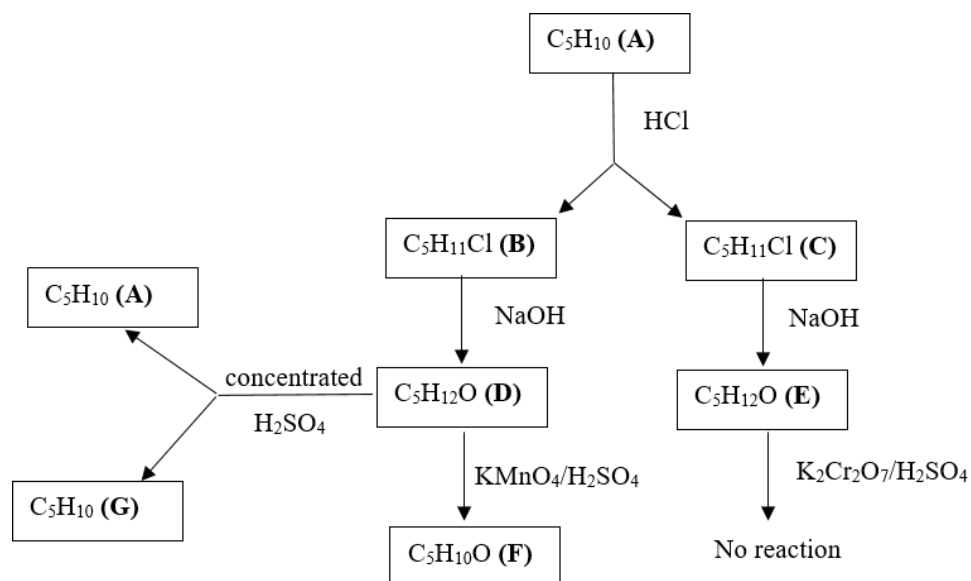
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Question 33 (7 marks)

This flowchart shows the reaction of seven different organic compounds (A to G).



Draw the structures of compounds A to G, justifying your structures with reference to the information provided.

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Compound	Structural formula	Justification
A		
B		

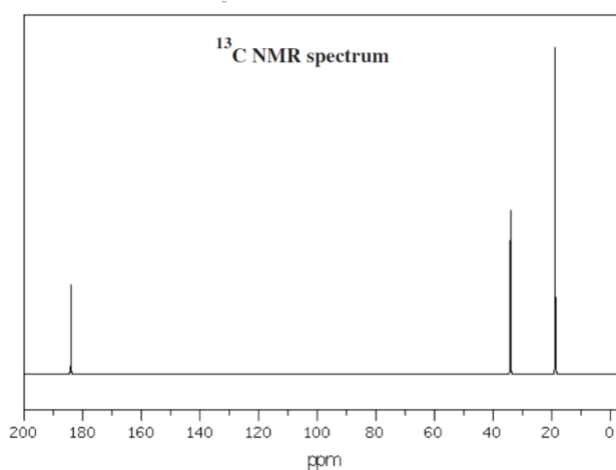
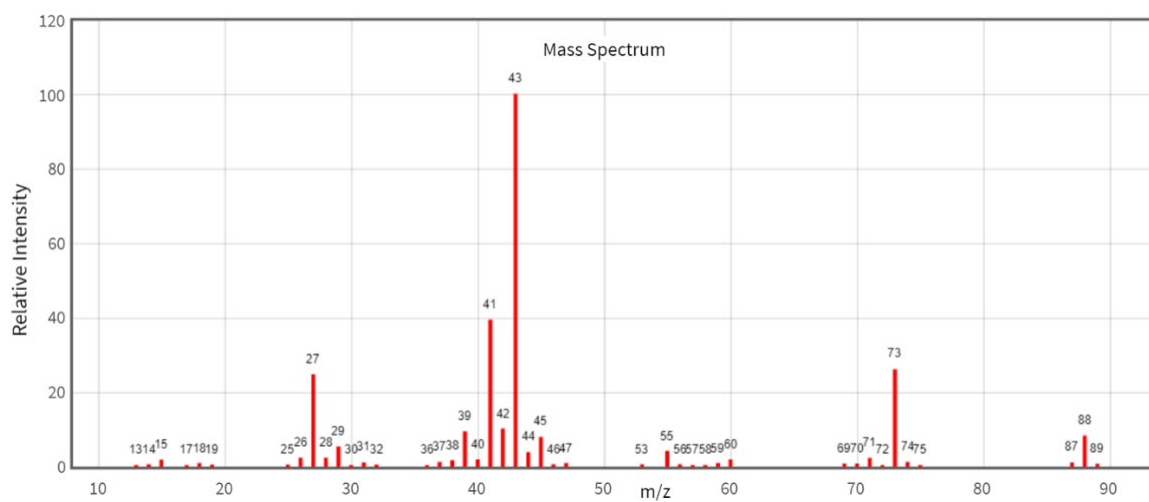
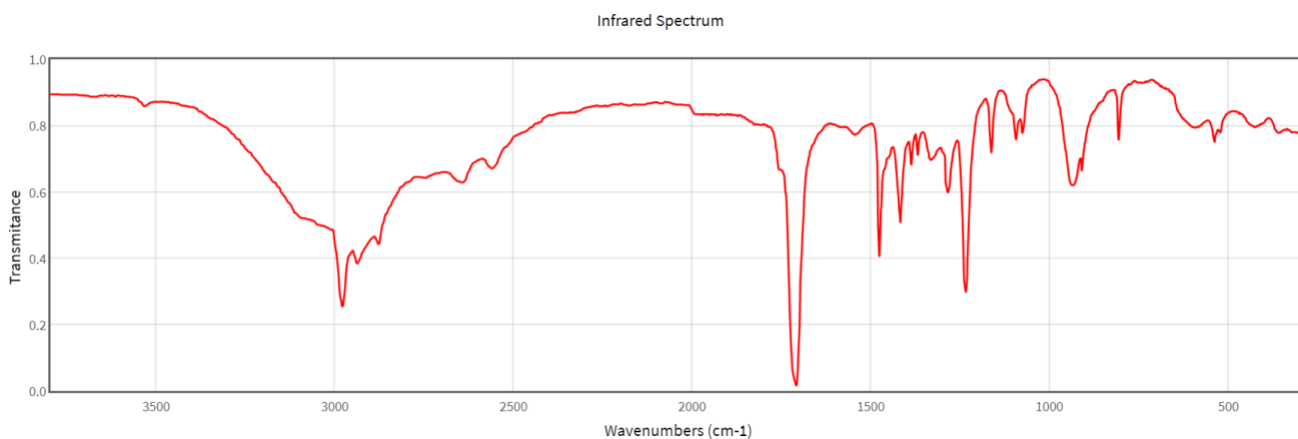
C		
D		
E		
F		
G		

End of Question 33

Question 34 (8 marks)

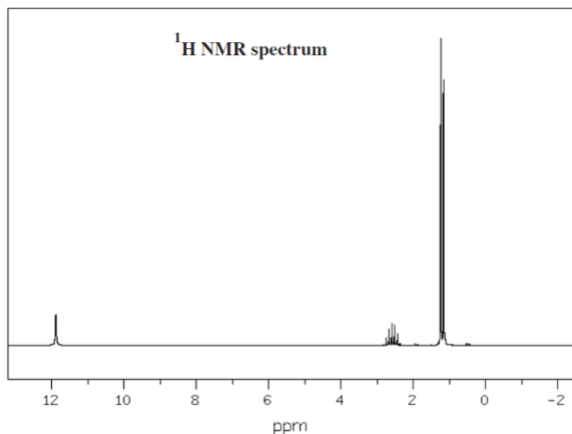
A chemist finds an unlabelled bottle containing a large quantity of compound Y, a colourless liquid. Elemental analysis gives an empirical formula of C_2H_4O .

To identify the molecular structure of compound Y, a sample is submitted for spectroscopic analysis. The following data were obtained.



Question 34 continues on page 31

Question 34 (continued)



<i>¹H NMR data</i>		
<i>Chemical shift data</i>	<i>Relative peak area</i>	<i>Peak splitting</i>
1.2	6	Doublet
2.6	1	Septet
11.9	1	Singlet

Draw the structural formula of compound Y. Justify your answer with reference to all FOUR of the provided spectra and describe a chemical test to confirm its identity.

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End of Question 34

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Section II extra writing space

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Section II extra writing space

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