SHORE

CHEMISTRY Trial Examination 2021

General Instructions

- Reading time 5 minutes
- Working Time 2 Hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- Answer Section I on the multiple choice answer sheet provided.
- Answer all other sections in your writing booklets. **Start each question on a new page**.
- Write your **Exam number on every page of the writing booklet.**
- Scan sections II, III and IV separately and upload to lampada.
- You should use the supplied NESA chemical formulae, data sheet and periodic table.

Section I: 20 marks

- Attempt question 1-20
- Allow about 30 minutes for this section

Section II: 16 marks

- Attempt questions 21 - 23
- Allow about 30 minutes for this section

Section III: 14 marks

- Attempt questions 24 - 25
- Allow about 25 minutes for this section

Section IV: 20 marks

- Attempt questions 26 - 28
- Allow about 35 minutes for this section

Note: Any time you have remaining should be spent revising your answers.

DO NOT REMOVE THIS PAPER FROM THE EXAMINATION ROOM

Section I - 20 marks
Attempt Questions 1–20
Allow about 35 minutes for this section

1. Ca^{2+} will form precipitates with solutions of ?

   (A) sodium chloride and sodium carbonate.

   (B) sodium sulfate and sodium carbonate.

   (C) sodium nitrate and sodium carbonate.

   (D) sodium chloride and sodium sulfate.

2. "X" is prepared from the reaction of "Y" and "Z" as described in the following equation.

$$Y(g) + Z(g) \rightleftharpoons 3X(g) \qquad \Delta H = -50 \text{ kJ mol}^{-1}$$

   Which set of conditions would optimise the yield of $X(g)$ that is produced?

   (A) High pressure, high temperature.

   (B) Low pressure, low temperature.

   (C) High pressure, low temperature.

   (D) Low pressure, high temperature.

3. Which one of the following would be classed as a weak, diprotic acid?

   (A) $H_2SO_4(aq)$

   (B) $H_2CO_3(aq)$

   (C) $CH_3COOH(aq)$

   (D) $CH_2(OH)CH_2OH(aq)$

4. Which statement about 100.0 mL of 0.10 mol L^{-1} hydrochloric acid and 100.0 mL of 0.10 mol L^{-1} acetic (ethanoic) acid solutions is correct?

   (A) Each solution will react completely with 100.0 mL of 0.10 mol L^{-1} sodium hydroxide solution.

   (B) The solutions will have the same electrical conductivity.

   (C) Each solution will react at the same rate with 1.00 g of magnesium ribbon.

   (D) The concentration of H_3O^+ ions will be the same in both solutions.

5. A mixture was prepared containing equal amounts of 0.10 mol L^{-1} ammonia solution and 0.10 mol L^{-1} ammonium nitrate.
Which statement about this mixture is correct?

(A) The mixture is strongly acidic.

(B) The mixture has a pH of approximately 7.

(C) The mixture will resist changes in pH when other solutions are added to it.

(D) The mixture will not change in pH when other solutions are added to it.

6. The pH of two solutions, X and Y, of the same concentration were measured. The pH of solution X was 2.00 and the pH of solution Y was 4.00. Which statement about solutions X and Y is correct?

(A) Solution Y must contain a stronger acid than solution X.

(B) The concentration of H^+ in solution X is two times greater than the concentration of H^+ in solution Y.

(C) The concentration of H^+ in solution X is 100 times greater than the concentration of H^+ in solution Y.

(D) The concentration of OH^- in solution Y is two times greater than the concentration of OH^- in solution X.

7. What is the function of the beam of electrons in a mass spectrometer?

(A) It detects the mass of the particles.

(B) It deflects the stream of positively charged particles.

(C) It bombards the sample causing ionisation to form positive particles.

(D) It removes positive particles from within the spectrometer.

8. Nitrous acid, HNO_2, has $K_a = 4.5 \times 10^{-4}$.

What is the best description of the species present in a 0.1 M solution of nitrous acid?

(A) HNO_2 *(aq)* is the predominant species; much smaller amounts of H^+ *(aq)* and NO_2^- *(aq)* are present.

(B) H^+ *(aq)* and NO_2^- *(aq)* are the predominant species; much smaller amounts of HNO_2 *(aq)* are present.

(C) Only H^+ *(aq)* and NO_2^- *(aq)* are present in measurable amounts.

(D) HNO_2 *(aq)*, H^+ *(aq)* and NO_2^- *(aq)* are all present in comparable amounts.

9. Question 9 relates to the endothermic reaction shown below.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g) \qquad K_{eq} \text{ is } 0.48 \text{ at } 100^\circ C$$

In an experiment it was found that the equilibrium concentration of $N_2O_4(g)$ was 0.20 mol/L. Calculate the concentration of the $NO_2(g)$ in this equilibrium mixture?

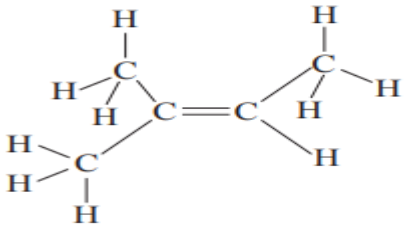
(A) 0.10 mol/L

(B) 0.31 mol/L

(C) 0.096 mol/L

(D) 3.23 mol/L

10. The molecule with the structural formula shown below reacts with hydrogen bromide, HBr, to form $C_5H_{11}Br$.



The number of different isomers of $C_5H_{11}Br$ which could be formed is(are)

(A) 1

(B) 2

(C) 3

(D) 4

11. A student mixed 10.0 mL of 0.0400 mol L^{-1} H_2SO_4 with 40.0 mL of 0.35 mol L^{-1} KOH.

What is the pH of the resulting solution?

(A) 0.26

(B) 0.59

(C) 13.42

(D) 13.45

Questions 12 and 13 relate to the following information:

Many industrial processes use the following reaction for the production of hydrogen gas.

$CO\ (g) + H_2O\ (g) \rightleftharpoons H_2\ (g) + CO_2\ (g) \quad \Delta H = -41\ kJ\ mol^{-1}$

12. Carbon monoxide, water vapour, carbon dioxide and hydrogen were pumped into a sealed container that was maintained at a constant temperature of 200°C.

After 30 seconds, the concentration of gases in the sealed container was found to be [CO] = 0.1 M, $[H_2O]$ = 0.1 M, $[H_2]$ = 2.0 M, $[CO_2]$ = 2.0 M.

The equilibrium constant at 200°C for the above reaction is K = 210.

Which one of the following statements about the relative rates of the forward reaction and the reverse reaction at 30 seconds is true?

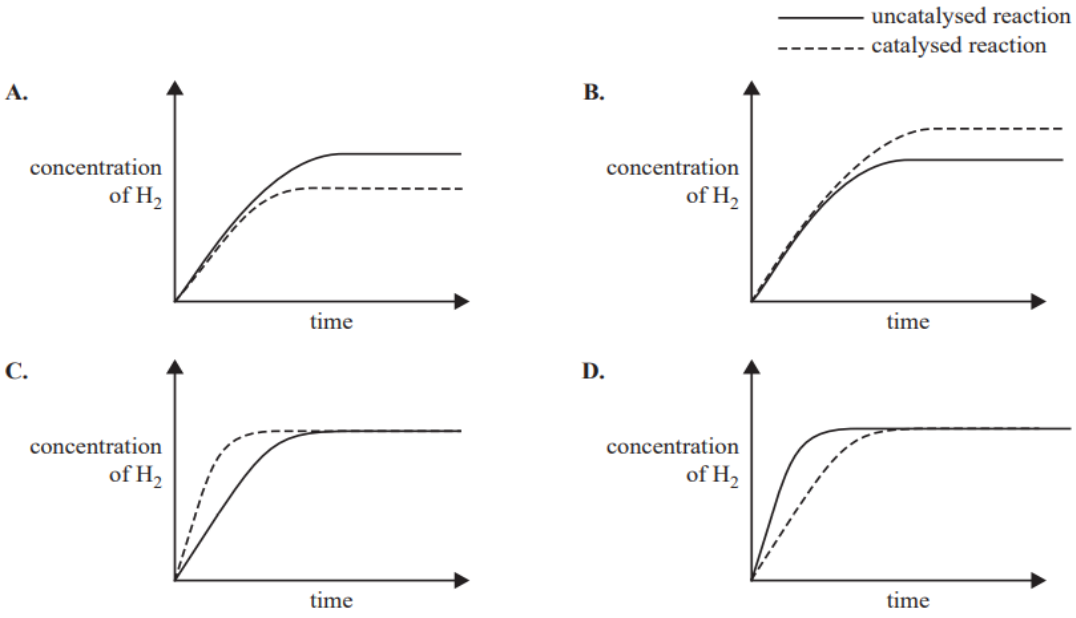
(A) The rate of the forward reaction is greater than the rate of the reverse reaction.

(B) The rate of the forward reaction is equal to the rate of the reverse reaction.

(C) The rate of the forward reaction is less than the rate of the reverse reaction.

(D) There is insufficient information to allow a statement to be made about the relative rates of the forward and reverse reactions.

13. In trials, the reaction is carried out with and without a catalyst in the sealed container. All other conditions are unchanged. The change in hydrogen concentration with time between an uncatalysed and a catalysed reaction is represented by a graph. Which graph is correct?



14. Precipitation titration can be used to determine the percentage by mass of certain ions in food samples.

The food sample was dissolved in water and the chloride ion was precipitated by adding an excess of silver nitrate solution. The precipitate was washed and dried.

The food sample had a mass of 20.0 g and the final precipitate a mass of 0.376 g.
Assume that the chloride ion in the food was caused by the addition of salt, sodium chloride, during the manufacture of the food product.

What was the percentage by mass of sodium chloride in the food?

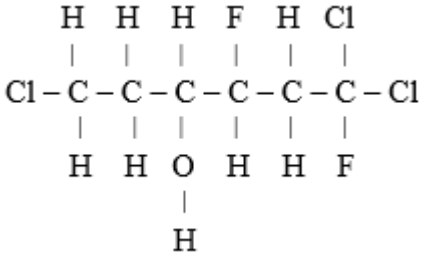
(A) 0.220%

(B) 0.465%

(C) 0.766%

(D) 1.88%

15. What is the correct I.U.P.A.C. name for the compound with formula shown below?



(A) 1,1,6-trichloro-1,3-difluorohexan-4-ol

(B) 1,3-difluoro-1,1,6-trichlorohexan-4-ol

(C) 1,6,6-trichloro-4,6-difluorohexan-3-ol

(D) 4,6-difluoro-1,6,6-trichlorohexan-3-ol

16. Consider the isomeric alcohols.

butan-1-ol butan-2-ol 2-methylpropan-2-ol 2-methylpropan-1-ol

Which of the following instrumental methods would most effectively differentiate between these isomeric alcohols?

(A) Atomic Absorption spectroscopy

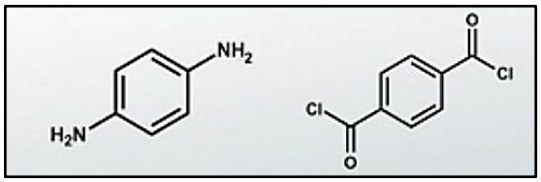
(B) Ultraviolet-visible spectrophotometry

(C) Infrared spectroscopy

(D) ^{1}H NMR spectroscopy

17. '*Kevlar*' is a type of polymer used to manufacture bullet-proof material due its very high tensile strength.

The monomers which react to form '*Kevlar*' are shown below.



Which of the following best accounts for the particularly high tensile strength of '*Kevlar*'?

(A) The ability of hydrogen bonds to form between the monomers.

(B) The ability of the polymer strands to form cross-linking covalent bonds.

(C) The strength of many of the bonds, such as C=O, within the polymer chain.

(D) The strength of the intermolecular forces formed between the polymer strands.

18. A solution containing $Co(H_2O)_6^{2+}$ *(aq)*, $CoCl_4^{2-}$ *(aq)* and Cl^- *(aq)* at equilibrium at room temperature is initially pink. When heated, the solution turns blue. Then, when Ag^+*(aq)* is added, the solution turns back to pink.

Which statements are correct?

I. $Co(H_2O)_6^{2+}$ *(aq)* is pink.
II. Formation of $CoCl_4^{2-}$ *(aq)* from $Co(H_2O)_6^{2+}$ *(aq)* and Cl^-*(aq)* is exothermic.

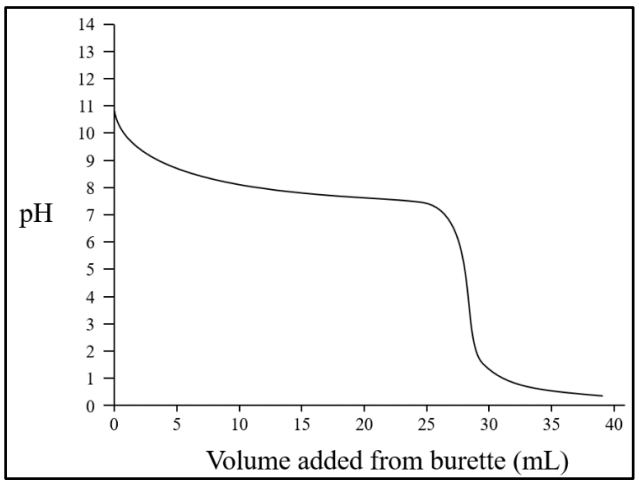
(A) I only

(B) II only

(C) Both I and II

(D) Neither I nor II

19. The curve below shows the change in pH vs the volume of solution added from a burette during an acid-base titration.



Which alternative identifies the type of solution present in the conical flask and burette during this titration?

	Solution in the conical flask	Solution in the burette
(A)	strong base	strong acid
(B)	weak base	strong acid
(C)	weak acid	weak base
(D)	strong acid	weak base

20. Barium fluoride has $K_{sp} = 1.8 \times 10^{-7}$.
What is the maximum fluoride ion concentration possible in a saturated solution.

(A) 6.0×10^{-8} M

(B) 1.2×10^{-7} M

(C) 3.6×10^{-3} M

(D) 7.1×10^{-3} M

Section II - 16 marks

Attempt Questions 21–23
Allow about 1 hour and 25 minutes for this section

Question 21 (6 marks)

Iron(III) ions and thiocyanate ions react to form a complex ion according to the following equation.

$$Fe^{3+}(aq) + SCN^{-}(aq) \rightleftharpoons FeSCN^{2+}(aq)$$

10.0 mL of a 0.00200 mol L^{-1} solution of iron(III) was added to 10.0 mL of a 0.00200 mol L^{-1} solution of thiocyanate ions and mixed. The mixture was tested after a period of time and the concentration of the iron thiocyanate complex was found to be 1.45×10^{-4} mol L^{-1}. Under the conditions used, the theoretical value of the equilibrium constant (K_{eq}) is 2.05×10^{2}.
Determine in which direction the reaction must proceed to reach equilibrium. Include the relevant calculations in your answer.

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Question 22 (5 marks)

A student added 1.78 g of $Ca(OH)_{2(s)}$ to 0.250 L of 0.200 mol L^{-1} $HNO_{3(aq)}$. The mixture was carefully stirred until no further reaction occurred.

(a) Assuming that the total volume of the solution remains unchanged, calculate the pH **3**

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(b) Explain how nitric acid can be regarded as both an Arrhenius acid and a Brønsted–Lowry acid. **2**

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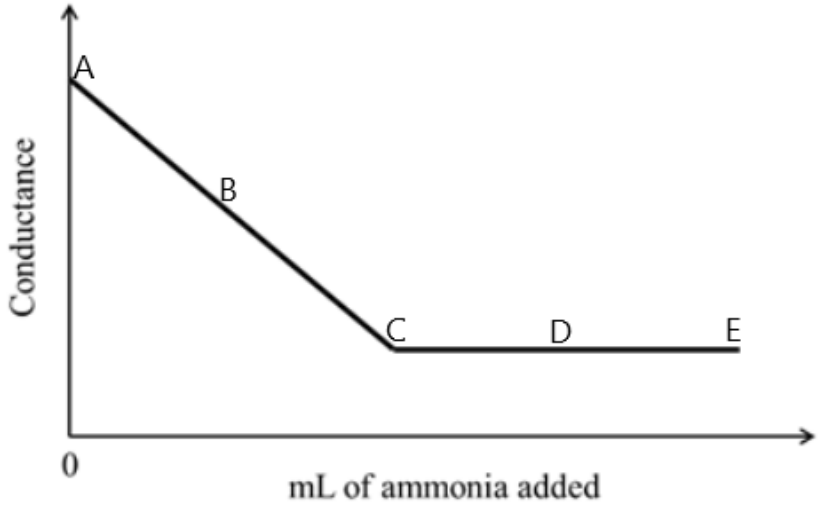
Question 23 (5 marks)

Conductivity curves show the change in conductivity during a titration.

The curve below was formed during the reaction of hydrochloric acid and ammonia.



(a) Which letter A-E most closely shows the equivalence point on the curve? **1**

(b) Account for the shape of the curve. **2**

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(c) One of the products of this reaction is ammonium chloride. With the aid of an equation explain why this salt is acidic, basic or neutral **2**

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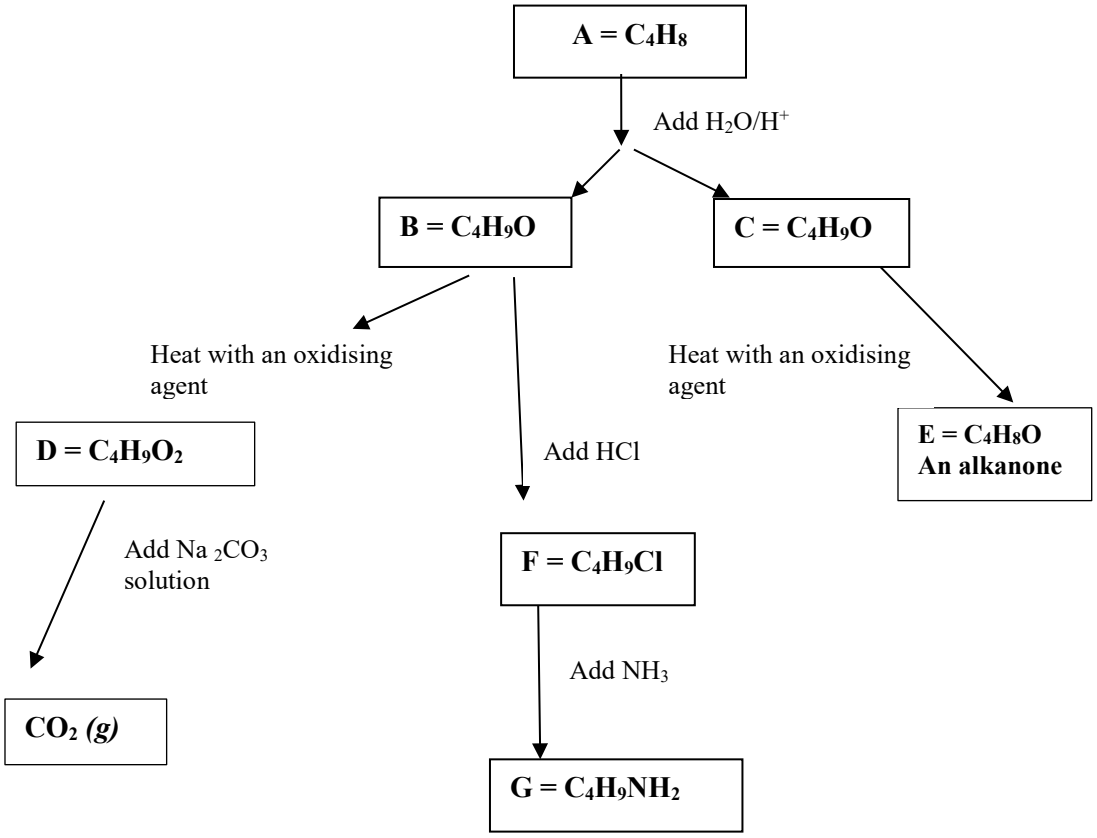
Section III - 14 marks. Attempt Questions 24–25. Allow about 25 minutes for this section

Question 24 (8 marks)

Use the flowchart to answer the questions below:



(a) Compound **A** reacts with dilute acid solution to form 2 different compounds with the same formula, compounds **B** and **C**. **3**
Identify compounds **A**, **B** and **C** by name and drawing structural formulae. Explain how you decided on the structures of **A**, **B** and **C**.

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Question 24 continues on the next page

Question 24 (continued)

(b) Write the balanced equation for the reaction of **D** with sodium carbonate solution. **1**

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(c) Write the equation for the reaction of **B** to form **F**. Draw the structural formula and name the organic product formed. **2**

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(d) Name and draw the structural formula for compound **G**. Into which homologous series of compounds is compound **G** classified? **2**

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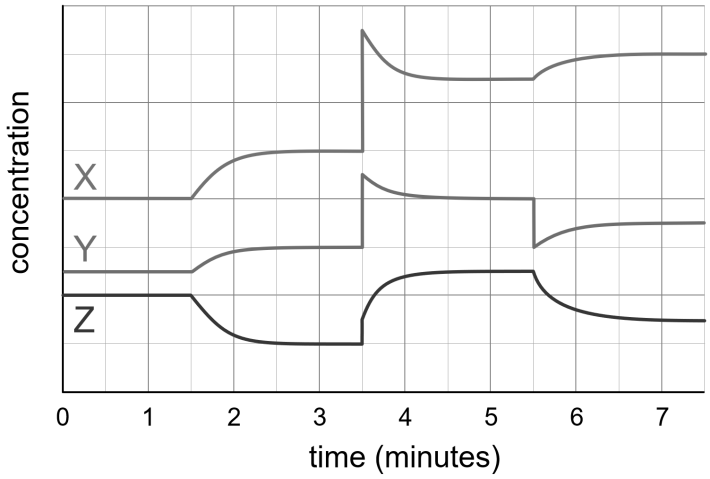
Question 25 (6 marks)

The graph shows the concentrations of three gas-phase species involved in a reversible decomposition reaction inside a closed container.

The decomposition reaction was known to be exothermic.



Infer from the data a possible balanced equation for the decomposition reaction, in terms of X, Y and Z, and explain the features of the graph in terms of: **6**

- Le Chatelier's Principle,
- the enthalpy change of the reaction and
- any disturbances to the system made by experimenters at various times.

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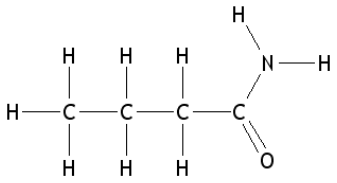
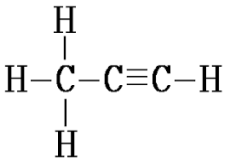
Section IV - 20 marks. Attempt Questions 26 – 28. Allow about 30 minutes for this section

Question 26 (7 marks)

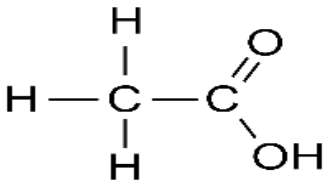
Using IUPAC nomenclature, name the compounds shown below. **3**



Compound 1



Compound 2



Compound 3

Compound 1 ……

Compound 2 ……

Compound 3 ……

Compare the intermolecular forces in the above 3 molecules and predict the order of boiling points (lowest to highest) of these molecules. Explain your prediction. **4**

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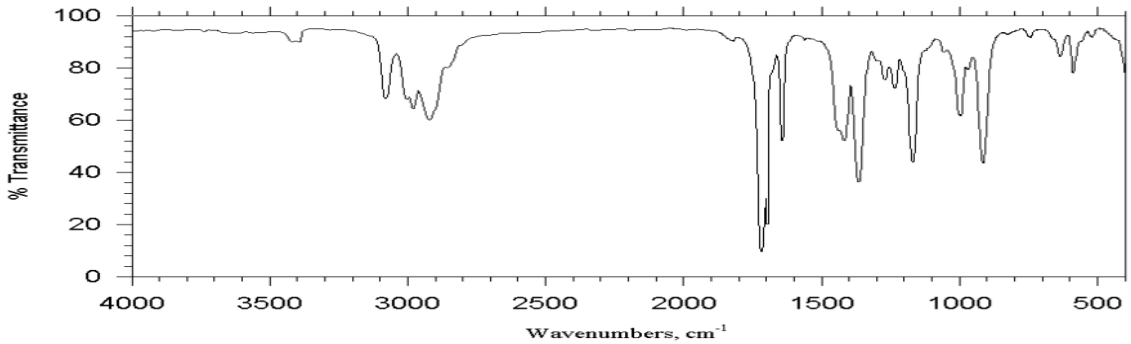
Question 27 (9 marks)

A scientist wished to identify an organic compound of formula C_4H_8O. The organic compound did not decolourise bromine water. She carried out instrumental analyses using 3 different types of spectroscopy.

(a) The IR spectrum is shown below. **2**



What do the regions 3100–4000 cm^{-1} and 1650–1700 cm^{-1} indicate about the bonds in C_4H_8O? Give your reasoning.

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(b) The ^{13}C-NMR spectrum of the unknown compound has four distinct peaks. Draw two possible structural formulas of the unknown compound using the information provided. **2**

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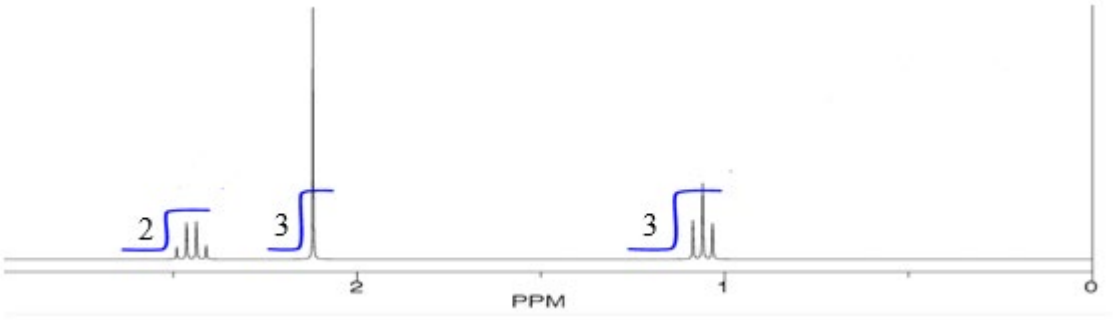
Question 27 continues on the next page

Question 27 (continued)

(c) The high-resolution ^{1}H NMR spectrum of the unknown compound has three peaks, as shown below. **3**



Use the high-resolution ^{1}H NMR spectrum to identify three pieces of information about the unknown compound and indicate how each would assist in determining its structure.

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(d) Describe a chemical test which could be used to distinguish between the 2 possible structures you have drawn in part (b) above. **2**

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Question 28 (4 marks)

A student was asked to derive a method that he could use in a school laboratory to distinguish between 4 unlabelled bottles with samples of solutions of $Pb(NO_3)_2$, $BaCl_2$, $FeSO_4$ and $MgSO_4$ using chemical reactions. **4**

Draw a flow chart to show the steps that could be followed to confirm the identity of each of the solutions. Include observed results.

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END OF EXAMINATION

MC

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

Question 21

initial total volume = 20.0 mL
= 0.0200 L

initial moles of Fe^{3+} and SCN^- = 0.0300×0.00200
= 0.0000600
= 6.00 $10\times^{-5}$ mol

initial moles of $FeSCN^{2+}$ = 0 mol

final $[FeSCN^{2+}]$ = 1.45 $10\times^{-4}$ mol L^-

	Fe^{3+}	SCN^-	$FeSCN^{2+}$
Initial number of moles	6×10^{-5}	6×10^{-5}	0
Change	-8.7×10^{-6}	-8.7×10^{-6}	$+8.7\times 10^{-6}$
Final number of moles	5.13×10^{-5}	5.13×10^{-5}	8.7×10^{-6}
Final concentration	8.55×10^{-4}	8.55×10^{-4}	1.45×10^{-4}

$$Q = \frac{[FeSCN^{2+}]}{[Fe^{3+}][SCN^-]}$$

$$= \frac{[1.45\ 10\times^{-4}]}{[8.55\ 10\times^{-4}][8.55\ 10\times^{-4}]}$$

$$= 198$$

In this case, $Q = 1.98 \times 10^2$ is less than $K = 2.05 \times 10^2$. Therefore, the reaction must shift to the right to reach equilibrium.

Mod 5 Calculating the Equilibrium Constant
CH12– 6, 12–12 Band 6

- Correctly calculates the reaction quotient.

AND

- Shows ALL relevant working.

AND

- Compares equilibrium constant to reaction quotient.

AND

- Determines the direction of the reaction 5– 6

- Correctly calculates the reaction quotient.

AND

- Shows SOME relevant working.

AND

- Compares equilibrium constant to reaction quotient.

OR

- Determines the direction of the reaction 4

- Correctly calculates the reaction quotient.

AND

- Shows SOME relevant working.

AND

- Refers to equilibrium constant AND reaction quotient.

OR

- Determines the direction of the reaction 3

- Shows SOME relevant working.

AND

- Refers to equilibrium constant AND reaction quotient 2

- Shows SOME relevant working.

OR

- Refers to equilibrium constant AND reaction quotient 1

NB we will need to pay carry over error ie if a student misses one step in the calculation eg doesn't convert back to conc from mole they will need to lose only 1 mark for each stage skipped. Not converting to moles at all will be -2 as they essentially skipped 2 steps.

Question 22

(a)	Equation for reaction: $2HNO_3(aq) + Ca(OH)_2(aq) \rightarrow Ca(NO_3)_2(aq) + 2H_2O(l)$ molar mass $= 40.08 + 2(16.00 + 1.008)$ $= 74.10$ g initial moles of $Ca(OH)_2 = \frac{\text{mass}}{\text{molar mass}}$ $= \frac{1.78}{74.10}$ $= 0.0240$ mol $\therefore$ initial moles of $OH^- = 0.0480$ mol initial moles of nitric acid $(HNO_3) = 0.250 \times 0.200$ $= 0.0500$ mol Nitric acid is in excess; therefore, the final number of moles of HNO_3 $(0.0500 - 0.0480) = 0.002$ mol. $[HNO_3]$ in excess $= \frac{0.002}{0.250}$ $= 0.008$ mol L^{-1} $pH = -\log[H^+]$ $= -\log[0.008]$ $= 2.097$ $= 2.10$	Mod 6 Properties of Acids and Bases Mod 6 Using Brønsted–Lowry Theory CH12–6, 12–13 Bands 5–6 • Uses correct stoichiometry. AND • Shows relevant calculations. AND • Calculates pH correctly . . . . . .3 • Uses correct stoichiometry. AND • Shows relevant calculations OR calculates pH correctly . . . . . .2 • Shows relevant calculations. OR • Calculates pH correctly 1
(b)	Nitric acid can be regarded as both an Arrhenius acid and a Brønsted–Lowry acid. An Arrhenius acid is a substance that dissociates in solution to produce hydrogen ion. For nitric acid: $HNO_3(aq) \rightarrow H^+(aq) + NO_3^-(aq)$ A Brønsted–Lowry acid is a substance that undergoes a hydrolysis reaction to produce $H_3O^+(aq)$. For nitric acid: $HNO_3(aq) + H_2O(l) \rightarrow H_3O^+(aq) + NO_3^-(aq)$ acid — base — conugate acid — conugate base	Mod 6 Properties of Acids and Bases CH12–13 Band 3 • Explains how nitric acid can be regarded as an Arrhenius acid. AND • Explains how nitric acid can be regarded as a Brønsted–Lowry acid . . . . . .2 • Any ONE of the above points 1

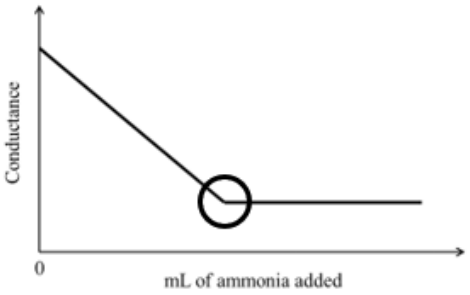
NB for a) they rounded too early and used the wrong number of sig figs. In pH conversions conc. Sig figs = pH d.p. I make the correct answer 2.107

Question 23 (4 marks)

(a)

Criteria	Marks
● Correctly identifies equivalence point on curve letter C	1

Sample answer:



(b)

Criteria	Marks
● Accounts for the shape of a strong acid/weak base curve in terms of HCl and NH_3, referring to the change in H_+ ion levels	3
● Identifies that hydrochloric acid is a strong acid and that ammonia is a weak base ● Describes some general aspects of the curve using appropriate scientific language	2
● Provides some relevant information	1

Sample answer:

Hydrochloric acid is a strong acid and ammonia is a weak base. Initially, there is a high conductivity due to presence of H^+ ions in the acid. Conductivity decreases as these H^+ ions react with ammonia molecules and are replaced by NH_4^+ ions, which have a lower conductivity. Once the equivalence point has been reached, conductivity does not change as more ammonia is added as it is a weak base and is only dissociated to a very small extent.

(c)

Criteria	Marks
● Correct equation ● Explains how the production of H_3O^+ makes the solution acidic	2
● Correct equation OR ● Explains how the production of H_3O^+ makes the solution acidic	1

$NH_{4(aq)} + H_20_{(l)}$ ⍰⍰ $NH_{3(aq)} + H_3O^+_{(aq)}$

Question 24

24 (a) (3 marks)

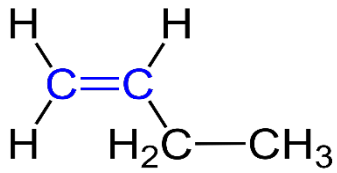
Outcomes Assessed: CH12–4, CH12–7, CH12–15

Targeted Performance Bands: 2-5

Criteria	Marks
• Identifies ALL of **A**, **B** and **C** by name and structural formula • Explains how the structures of **A**, **B** and **C** were determined • Identifies A as alkene with justification. Name AND structure is coherent • B as primary alcohol with justification Name AND structure is coherent • C as secondary alcohol with justificaiton. Name AND structure is coherent	3
• Identifies TWO of **A**, **B** and **C** by name and structural formula • Explains how the structures of TWO of **A**, **B** and **C** were determined	2
• Identifies ONE of **A**, **B** and **C** by name and structural formula • Identifies some correct information about the structures of **A**, **B** or **C**	1

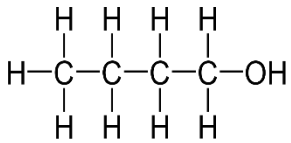
Sample answer

A is but-1-ene.



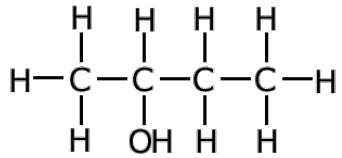
It cannot be but-2-ene as but-2-ene is symmetrical and would only form 1 alcohol on addition of water.

B is butan-1-ol.



Butan-1-ol is a primary alcohol and can be oxidised to form an acid (here **D**).

C is butan-2-ol.



Butan-2-ol can be oxidised to form an alkanone, C_4H_8O**H**

29 (b) (1 mark)

Outcomes Assessed: CH12–7, CH12–15

Targeted Performance Bands: 3-4

Criteria	Mark
● Writes the correct equation for the reaction of **D** with sodium carbonate solution.	1

Sample answer

$2CH_3CH_2CH_2COOH\ (aq) + CO_3^{2-}\ (aq) \rightarrow CO_2\ (g) + H_2O\ (l) + 2CH_3CH_2CH_2COO^-\ (aq)$

29 (c) (2 marks)

Outcomes Assessed: CH12–7, CH12–15

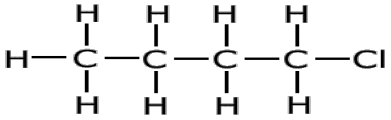
Targeted Performance Bands: 2-4

Criteria	Marks
● Writes the correct equation for the reaction of **B** (butan-1-ol) with HCl AND ● Names the organic product and draws its structure	2
● Writes the correct equation for the reaction of **B** (butan-1-ol) with HCl OR ● Names the organic product and draws its structure	1

Sample answer

$CH_3CH_2CH_2CH_2OH\ (l) + HCl\ (aq) \rightarrow CH_3CH_2CH_2CH_2Cl\ (l) + H_2O\ (l)$

1-chlorobutane is formed.



29 (d) (2 marks)

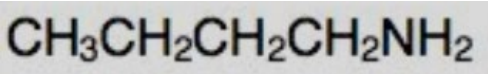
Outcomes Assessed: CH12–7, CH12–15

Targeted Performance Bands: 2-4

Criteria	Marks
● Names the compound **G** and draws its structure ● Classifies **G** as an amine	2
● Names **G** correctly OR correctly draws its structural formula OR identifies it as an amine.	1

Sample answer

G is butan-1-amine (1-aminobutane).



It is classified as an amine (or as an aminoalkane).

Question 25

Marking Criteria	Marks
1 mark each for: ● equation with stoichiometry: $2Z(g) \rightleftharpoons 2X(g) + Y(g)$ ● disturbance at t = 1.5 mins = decrease in temp ● LCP at t= 1.5 mins (shift to the side to produce MORE heat, FORWARD) ● disturbance at t = 3.5 mins = ⅔ decrease in volume as 3/2 increase in concentration = increase in pressure ● LCP at t = 3.5 (shift to the side that produces LESS moles,REVERSE) ● disturbance at t = 5.5 mins = removal of some 'Y' AND LCP reasoning (shift to the side that makes more Y, FORWARD ● Le Chatelier's Principle ● correctly identified stoichiometric ratios of the species shown by a balanced equation ● correctly identified enthalpy change of the reaction AND ● any disturbances to the system made by experimenters at various times.	**6**
Explains most major features of the graph in terms of at least 3 of the following: ● Le Chatelier's Principle ● correctly identified stoichiometric ratios of the species shown by a balanced equation ● correctly identified enthalpy change of the reaction AND ● any disturbances to the system made by experimenters at various times.	**5**
Explains most major features of the graph in terms of at least 2 of the following: ● Le Chatelier's Principle ● correctly identified stoichiometric ratios of the species ● correctly identified enthalpy change of the reaction AND ● any disturbances to the system made by experimenters at various times.	**4**
Explains TWO features of the graph in terms of one or more of the following ● Le Chatelier's Principle ● correctly identified stoichiometric ratios of the species ● correctly identified enthalpy change of the reaction AND ● any disturbances to the system made by experimenters at various times.	**3**
Describes TWO features shown in the graph and demonstrates some understanding of any of the following: ● Le Chatelier's Principle ● correctly identified stoichiometric ratios of the species ● correctly identified enthalpy change of the reaction AND ● any disturbances to the system made by experimenters at various times. ● to attempt to explain the features described	**2**
● Provides some relevant information.	**1**

Between t = 0 and 1.5 min the system is at equilibrium, as seen by the constant concentration of each gas in the system (rates of forward and reverse reactions must be equal for concentrations to remain constant).
At t = 1.5 min, a change in temperature occurred, as seen by the changing concentrations of all species. Since X and Y increase, but Z decreases, X and Y must be present on the same 'side' of the equation. As the equation is a decomposition reaction, the equation must be:
$Z(g) \rightleftharpoons X(g) + Y(g)$
Since the forward reaction was favoured, which is exothermic, the temperature must have been decreased at t=1.5, as cooling a system favours the exothermic reaction which released some heat energy, thereby minimising the effect of the disturbance imposed (as suggested by Le Chatelier's Principle).

At t=3.5 min, the concentrations of all species increase, suggesting the volume of the vessel decreased.
All concentrations increased by a factor of 1.5×, indicating that the volume was decreased to 2/3 of its original value.
When volume of the reaction vessel decreases, a shift to the side that produces less moles of gas occurs, to minimise the effect of the volume decrease. This is consistent with the change shown in the graph at 3.5 min, with the concentrations of X and Y decreasing (at different rates due to reaction stoichiometry), while the concentration of Z increases.
At t=5.5 min, the concentration of Y suddenly decreases, suggesting some of this product may have been removed at this time. According to Le Chatelier's Principle, removal of a product will shift the equilibrium to the side that minimises the effect of the removal ie to the right. This is consistent with the increases in concentration of both X and Y shown after the removal, and fall in that of Z.

Question 26

Outcomes Assessed: CH12–4, CH12–7, CH12–14

Targeted Performance Bands: 3-5

Criteria	Marks
● Names THREE compounds correctly	3
● Names TWO compounds correctly	2
● Names ONE compound correctly	1

Sample answer

Compound 1 = butanamide

Compound 2 = propyne

Compound 3 = ethanoic acid

26 (b) (4 marks)

Outcomes Assessed: CH12–5, CH12–7, CH12–14

Targeted Performance Bands: 2-6

Criteria	Marks
● Predicts the correct order of boiling points (Compound 2, Compound 3, Compound 1) ● Explains thoroughly the impact of the different intermolecular forces ● Identifies that Compound 1 has very strong hydrogen bonding and greater mass and chain length than Compound 3 ● Identifies that Compound 2 has dispersion (temporary dipole-dipole forces) only ● Identifies that Compound 3 has hydrogen bonding (2 hydrogen bonds form between adjacent molecules)	4

• Predicts the correct order of boiling points • Explains thoroughly the impact of the different intermolecular forces • Identifies the intermolecular forces in 2 of the 3 compounds	3

• TWO of:
  • Predicts the correct order of boiling points
  • Explains thoroughly the impact of the different intermolecular forces
  • Identifies the intermolecular forces in 2 of the 3 compounds
OR
  • Identifies the intermolecular forces in all 3 compounds
	2

• ONE of:
  • Predicts the correct order of boiling points
  • Identifies the intermolecular forces in 1 of the 3 compounds
	1

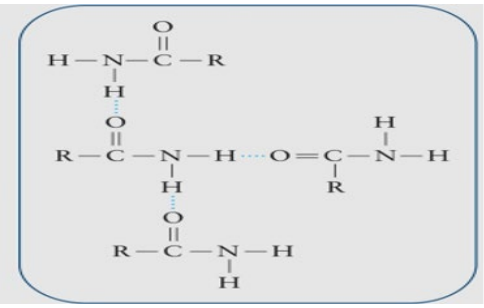
Sample answer

The order of increasing boiling points is Compound 2, Compound 3, Compound 1.

The stronger the intermolecular forces, the higher the boiling point, as greater energy is needed to separate the liquid molecules to form a gas.

Compound 2 is non-polar and has only weak intermolecular forces (dispersion or temporary dipole-dipole forces) caused by the electrical interaction of molecules as they collide (protons from 1 molecule being attracted to electrons from the other as the molecules are temporarily distorted on collision).

Compound 1 is polar and would experience very strong hydrogen bonding forces, as well as weaker temporary and permanent dipolar forces) as molecules interact. These are strong intermolecular forces as hydrogen bonds can also form between the oxygen of 1 molecule and the hydrogen of the -NH_2 group. The geometry of the molecules allows more than 1 H-bond per molecule at any instant. Butanamide has a boiling point of 213°C and hence is a solid at room temperature. This boiling point is higher than that of Compound 3, as Compound 1 has greater mass and chain length than ethanoic acid. Both form hydrogen bonds between neighbouring molecules.



Compound 3 is an alkanoic acid and has the very polar –COOH functional group. The hydrogen atom of the –COOH can form a hydrogen bond with an oxygen of the neighbouring acid molecule. The planar nature of this –COOH group allows 2 H-bonds per pair of molecules.

Hence the intermolecular forces and thus boiling points are highest in Compound 1 and lowest in Compound 2.

Question 27

27 (a) (2 marks)

Outcomes Assessed: CH12–5, CH12–7, CH12–15

Targeted Performance Bands: 3-5

Criteria	Marks

● From the 3100-4000 cm^{-1} region:
  ● Identifies that there are no –OH bonds in the molecule so the compound is not an alcohol or acid
● From the 1650-1700 cm^{-1} region:
  ○ Identifies that a carbonyl group is in the molecule so the molecule is likely to be an aldehyde or ketone
	2

● Identifies that the molecule is NOT an alcohol OR ● Identifies that the compound is not an acid OR ● Identifies that the compound contains a carbonyl group	1

Sample answer

The compound contains carbon, hydrogen and oxygen (given in question). We know from the absence of characteristic absorption in the 3100-4000 cm^{-1} region, that the compound is not an acid or an alcohol as there is no evidence of –OH functional group in acids or alcohols in the 3100-4000 cm^{-1} range as the broad absorption region characteristic of acids or alcohols is absent.

It is likely to be an alkanal or an alkanone, given that it has only 1 oxygen and is not an ester, (as has only 1 oxygen).

There is positive indication of a carbonyl group (as evidenced by the absorption in the 1650-1700 cm^{-1} region.

It does not contain carbon-carbon double or triple bonds as it does not react with bromine water.

29 (b) (2 marks)

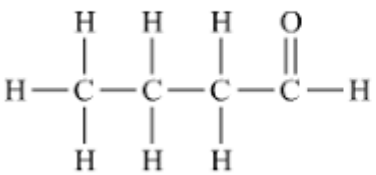
Outcomes Assessed: CH12–5, CH12–7, CH12–14, CH12–15

Targeted Performance Bands: 3-5

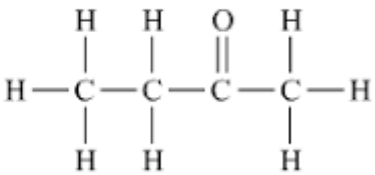
Criteria	Marks
● Draws 2 possible structures	2
● Draws 1 possible structure	1

Sample answer

Butanal



Butanone



Both structures would result in 4 distinct peaks on a ^{13}C-NMR spectrum. Note: butanal can have a branched carbon chain but that would only have 3 distinct peaks.

29 (c) (3 marks)

Outcomes Assessed: CH12–5, CH12–7, CH12–15

Targeted Performance Bands: 3-6

Criteria	Marks
● Identifies THREE pieces of information from the ^{1}H-NMR spectrum	3
● Identifies TWO pieces of information from the ^{1}H-NMR spectrum	2
● Identifies ONE piece of information from the ^{1}H-NMR spectrum	1

Sample answer

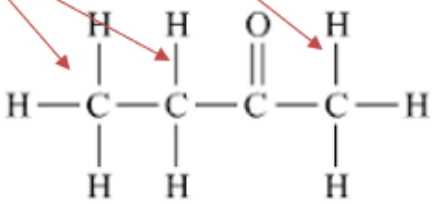
The spectrum shows that the compound has the 8 hydrogen atoms in 3 different environments.

There are 3 hydrogens which do not have another hydrogen atom on an adjacent atom. This corresponds to a $CH_3–CO–$ structure as seen in butanone.

There are 3 hydrogens which have 2 hydrogens on an adjacent atom. This corresponds to a molecule with an ethyl group, $–CH_2CH_3$.

There are 2 hydrogens which have 3 hydrogen on adjacent atoms.

Butanone



Hence the unknown is butanone.

29 (d) (2 marks)

Outcomes Assessed: CH12–5, CH12–7, CH12–14

Targeted Performance Bands: 3-4

Criteria	Marks
● Describes a chemical test including method and observations, which could be used to distinguish between the 2 possible structures with the conclusion that oxidation would indicate aldehyde and non- oxidation would indicate ketone. NB must describe test	2
● Identifies a chemical test which could be used to distinguish between the 2 possible structures	1

NB accept carry over error from b)

Sample answer

The sample could be reacted in a test tube with acidified potassium dichromate solution, which is orange. If, on heating and shaking, the orange colour changes to green, then the unknown would have been oxidised. This would have indicated that the unknown was butanal.

If no colour change occurs, the unknown is butanone.

Question 28

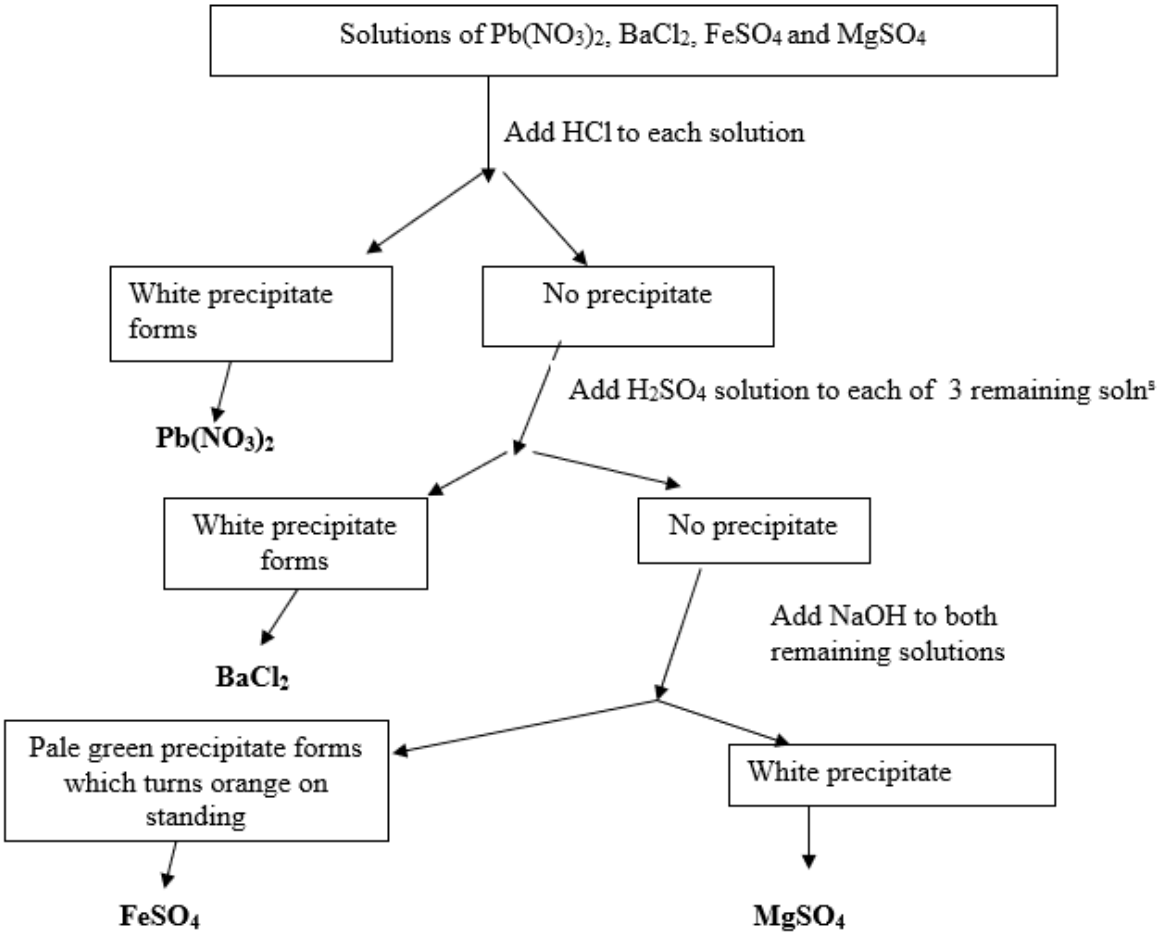
24 (a) (4 marks)

Outcomes Assessed: CH12–2, CH12–7, CH12–15

Targeted Performance Bands: 2-5

Criteria	Marks
● Draws a flow chart to show a correct method of identification of ALL FOUR solutions ● Includes all observations	4
● Draws a flow chart to show a correct method of identification of THREE solutions ● Includes correct observations for the 3 correctly identified solutions	3
● Draws a flow chart to show a correct method of identification of TWO solution ● Includes correct observations for the 2 correctly identified solutions	2
● Draws a flow chart and includes some correct information	1

Sample answer (several possible answers)


Solutions of $Pb(NO_3)_2$, $BaCl_2$, $FeSO_4$ and $MgSO_4$
Add HCl to each solution
White precipitate forms
No precipitate
$Pb(NO_3)_2$
Add H_2SO_4 solution to each of 3 remaining soln^s
White precipitate forms
No precipitate
$BaCl_2$
Add NaOH to both remaining solutions
Pale green precipitate forms which turns orange on standing
White precipitate
$FeSO_4$
$MgSO_4$