Baulkham Hills Chemistry Trial

1. Consider the equilibrium process: $CH_2CH_{2(g)} + H_{2(g)} \rightleftharpoons CH_3CH_{3(g)} \qquad \Delta H = -136 \text{kJmol}^{-1}$
   Which of the following changes would cause the magnitude of the equilibrium constant to increase?

   (a) The temperature is decreased.

   (b) The pressure is decreased.

   (c) The concentration of H_2 in the equilibrium mixture is increased.

   (d) The concentration of CH_3CH_3 in the equilibrium mixture is increased.

2. Phosphorus pentachloride gas undergoes an equilibrium with phosphorus trichloride and chlorine gas according to the following equation:

$$PCl_{5(aq)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$$

   0.2 moles of phosphorus pentachloride was placed in a sealed 2L container so that equilibrium could be achieved. The container was found to hold 0.15 moles of chlorine gas. What is the equilibrium value (K) for this reaction?

   (a) 0.225

   (b) 0.315

   (c) 0.450

   (d) 1.333

3. At a certain temperature, K for the following reaction is 75:

$$2\,O_{3(g)} \rightleftharpoons 3\,O_{2(g)}$$

   0.3mol of O_3 and 1.5mol of O_2 were introduced into a 5L reaction vessel. Which is the direction of the equilibrium shift and the reason for the shift?

	Direction Favoured	**Reason**
(a)	Left	$Q > K$
(b)	Left	$Q < K$
(c)	Right	$Q > K$
(d)	Right	$Q < K$

4. Consider this equilibrium reaction for BOTH questions 4 and 5:

$$2\,ClF_{3(aq)} \rightleftharpoons 3\,F_{2(g)} + Cl_{2(g)} \qquad \Delta H < 0$$

   An expression for the equilibrium constant is:

   (a) $\frac{[ClF_3]}{[F_2]^3[Cl_2]}$

   (b) $\frac{3[F_2][Cl_2]}{2[ClF_3]}$

   (c) $\frac{[F_2]^3[Cl_2]}{[ClF_3]^2}$

   (d) $\frac{2[ClF_3]}{3[F_2][Cl_2]}$

5. For the equilibrium reaction, the temperature is lowered and the amount of ClF_3 then changed by 0.150mol. The changes occurring would be:

	$[ClF_3]$	$[F_2]$	$[Cl_2]$
(a)	Increase by 0.150mol	Decrease by 0.225mol	Decrease by 0.075mol
(b)	Increase by 0.150mol	Decrease by 0.100mol	Decrease by 0.075mol
(c)	Decrease by 0.150mol	Increase by 0.225mol	Increase by 0.075mol
(d)	Decrease by 0.150mol	Increase by 0.100mol	Increase by 0.075mol

6. Which of the following hydrocarbons has a higher boiling point than pentane?

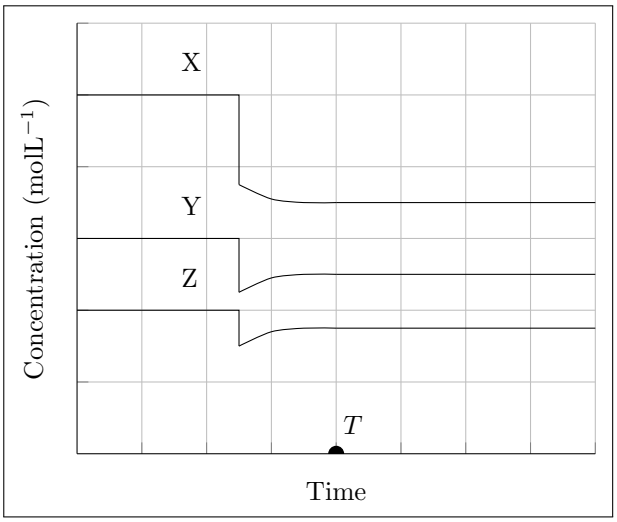
   (a) Pent-1-ene

   (b) Hex-1-ene

   (c) Pent-2-yne

   (d) 2-methylbutane

7. Three gases X, Y and Z were mixed in a closed container and allowed to reach equilibrium. A change was imposed at time T, and equilibrium was then re-established. The concentration of each gas is plotted against time. What is the equilibrium equation?



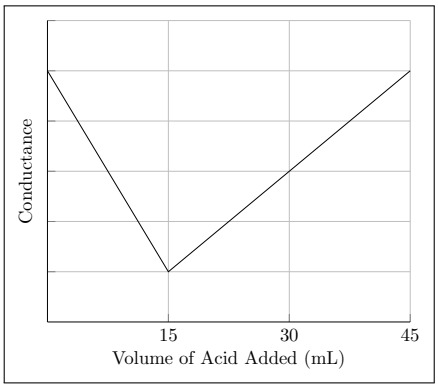
   (a) $X_{(g)} + Y_{(g)} \rightleftharpoons 2\,Z_{(g)}$

   (b) $2\,X_{(g)} \rightleftharpoons Y_{(g)} + Z_{(g)}$

   (c) $2\,X_{(g)} \rightleftharpoons Y_{(g)} + 3\,Z_{(g)}$

   (d) $X_{(g)} \rightleftharpoons Y_{(g)} + Z_{(g)}$

8. 20mL of KOH solution was titrated with 0.20molL^{-1} H_2SO_4 solution in a conductivity cell. The data obtained was plotted to give the graph shown below:



The concentration of the KOH solution is:

(a) 0.30molL^{-1}

(b) 0.15molL^{-1}

(c) 0.12molL^{-1}

(d) 0.075molL^{-1}

9. In a titration of a strong base with a strong acid, the following procedure was used:
   1. A burette was rinsed with water and then filled with the standard acid.
   2. A pipette was rinsed with some base solution.
   3. A conical flask was rinsed with some base solution.
   4. A pipette was used to transfer a measured volume of base solution into the conical flask.
   5. Indicator was added to the base sample and it was titrated to the endpoint with the acid.

   Which statement is correct?

(a) The calculated base concentration will be correct.

(b) The calculated base concentration will be too low.

(c) The calculated base concentration will be too high.

(d) No definite conclusion can be reached about the base concentration.

10. Consider the system:

$$HF_{(aq)} + H_2O_{(l)} \rightleftharpoons F^-_{(aq)} + H_3O^+_{(aq)}$$

Which of the following represents a conjugate acid-base pair present in this system?

(a) $HF_{(aq)}/F^-_{(aq)}$

(b) $HF_{(aq)}/H_3O^+_{(aq)}$

(c) $HF_{(aq)}/H_2O_{(l)}$

(d) $F^-_{(aq)}/H_3O^+_{(aq)}$

11. The table below gives the heat of combustion in kJg^{-1} for a number of different fuels:

Fuel	**Heat of Combustion (kJg^{-1})**
Methanol	22.7
Ethanol	29.6
Propanol	33.6
Petrol (octane)	47.8

The heat of combustion for one of these fuels was calculated as $2016 kJmol^{-1}$. What was the fuel?

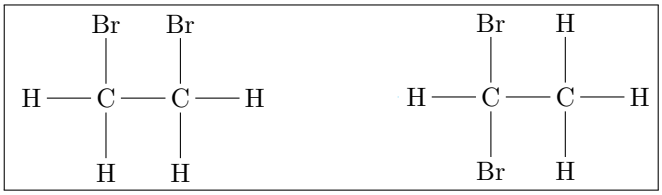
(a) Methanol

(b) Ethanol

(c) Propanol

(d) Petrol (octane)

12. Which term describes the relationship between the two compounds shown below?



(a) Allotropes

(b) Isomers

(c) Isotopes

(d) Monomers

13. Consider the following two compounds:

X: CH_3COOH

Y: $CH_3CH_2NH_2$

Which of the following best describes the properties of compound **X** and **Y**?

(a) Both compounds are acidic.

(b) Both compounds are basic.

(c) Compound **X** is basic and compound **Y** is acidic.

(d) Compound **X** is acidic and compound **Y** is basic.

14. A hydrocarbon has the following condensed structural formula:

$$CH_3CH_2CH_2CH_2CH_2CHCHCH_3$$

It is mixed with pure bromine liquid. The name of the product of the addition reaction is:

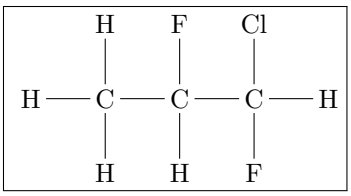
(a) Dibromooctane

(b) 2,3-dibromooctane

(c) 6,7-dibromooctane

(d) 3-bromooctan-2-ol

15. What is the name of the compound shown?



(a) 1-chloro-1,2-difluoropropane

(b) 3-chloro-2,3-difluoropropane

(c) 1,2-difluoro-1-chloropropane

(d) 1-chloro-1,2-difluoropentane

16. How many hydrogen atoms are there on one molecule of 2,2-dimethylbutan-1-ol?

(a) 8

(b) 10

(c) 12

(d) 14

17. What volume of a 0.20molL^{-1} solution of calcium hydroxide solution would be required to neutralise 150mL of a 0.15molL^{-1} solution of hydrochloric acid?

(a) 11mL

(b) 23mL

(c) 45mL

(d) 56mL

18. In an experiment, 4-hydroxybutanoic acid [$HO(CH_2)_3COOH$] forms a polymer containing 1000 monomer units. Which of the following is closes to the approximate molar mass (in gmol^{-1}) of this polymer?

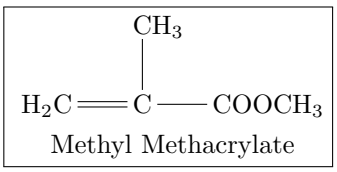
(a) 2.0×10^2

(b) 1.4×10^4

(c) 8.6×10^4

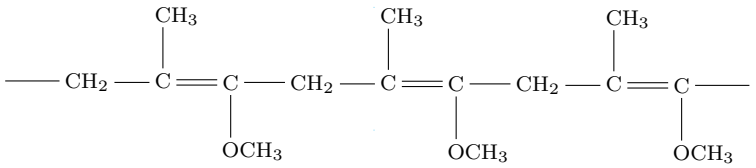
(d) 1.0×10^5

19. Which polymer is made by the polymerisation of methyl methacrylate?

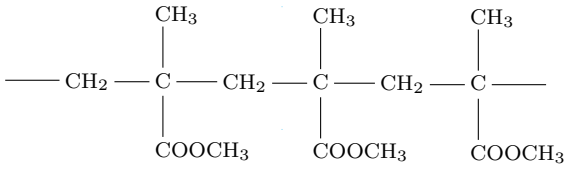


Methyl Methacrylate

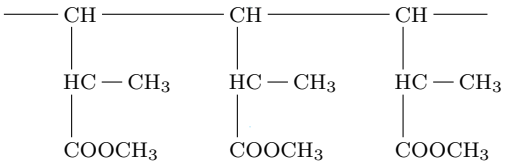
(a)



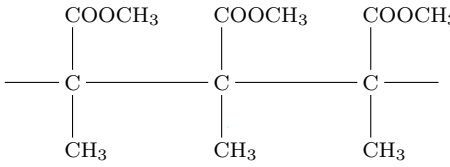
(b)



(c)



(d)



20. How many peaks would appear on the ^{13}C NMR spectrum of pentan-3-one?

(a) 2

(b) 3

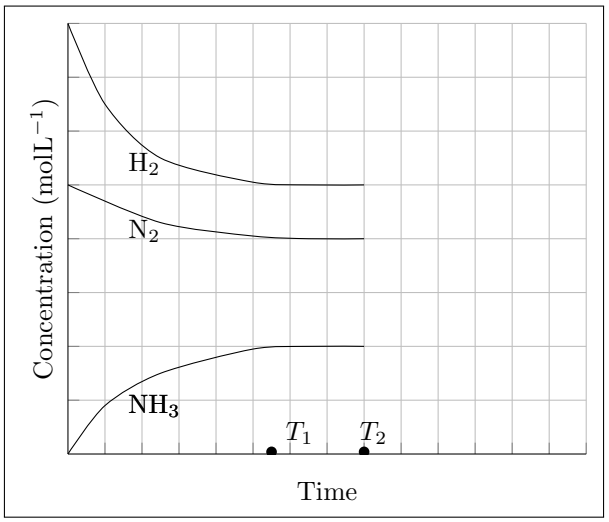
(c) 4

(d) 5

Section 2

21. The graph shows the variation in concentrations of reactants and products with time for the Haber Process:

$$N_{2(g)} + 3\,H_{2(g)} \rightleftharpoons 2\,NH_{3(g)} \qquad \Delta H < 0$$



At time T_2, the volume of the reaction vessel was reduced.

(a) Sketch on the graph how the concentrations of reactants and product would change after the volume was reduced. **2**

(b) Explain the changes on your graph. **2**

22.

(a) The K_{sp} for calcium fluoride is 1.00×10^{-11}. Calculate the solubility of calcium fluoride in molL^{-1} in water at 25°C. **3**

(b) Consider the reaction below: **3**

$$CH_{4(g)} = 2\,H_2S_{(g)} \rightleftharpoons CS_{2(g)} + 4\,H_{2(g)} \qquad K = 3.6 \text{ at } 1173\text{K}$$

Given the concentrations recorded in the table, explain whether the reaction is at equilibrium, or favours the reactants or products.

Substance	**Concentration (M)**
CH_4	1.07
H_2S	1.20
CS_2	0.90
H_2	1.78

23.

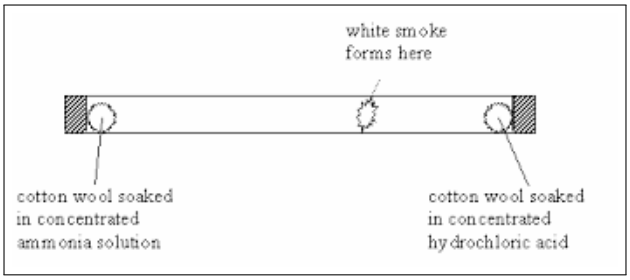
(a) Methane and water vapour react to form carbon monoxide and hydrogen in a closed container, as shown: **3**

$$CH_{4(g)} + H_2O_{(g)} \rightleftharpoons CO_{(g)} + 3\,H_2(g) \qquad \Delta H = 206\text{kJmol}^{-1}$$

Compare the impact on the equilibrium system of a decrease in the volume of the container to the impact of a decrease in temperature. Refer to the equilibrium constant in your answer.

(b) Solid ammonium hydrogen sulfide (NH_4HS) decomposes to form ammonia gas and hydrogen sulfide gas (H_2S). 2.00 moles of ammonium hydrogen sulfide were placed in a sealed 3.00L container and the system was allowed to reach equilibrium. At equilibrium, there were 0.0328 moles of ammonia gas. Calculate the equilibrium constant for this reaction. **4**

24. The equipment shown is set up. After some time, a ring of white powder is seen to form on the inside of the glass tube. **4**



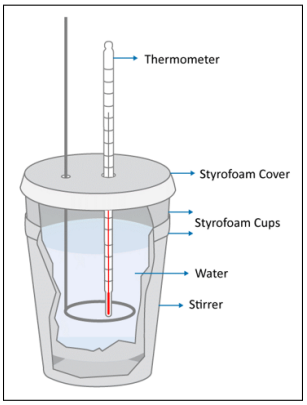
Would this reaction be considered an Arrhenius or Bronsted-Lowry acid-base reaction? Use a balanced chemical equation to justify your choice.

25. An antacid tablet is known to contain calcium carbonate ($CaCO_3$). To determine the mass of calcium carbonate in the tablet, the following procedure was used:
1: The tablet was crushed and placed in a beaker
2: A pipette was used to add 25mL of 0.600molL^{-1} of hydrochloric acid to the crushed tablet in the beaker.
3: Once the reaction between calcium carbonate and hydrochloric acid had stopped, phenolphthalein indicator was added to the reaction mixture.
4: A teflon-coated burette was then used to add 0.100molL^{-1} sodium hydroxide to the beaker to neutralise the excess hydrochloric acid.
5: The phenolphthalein changed from colourless to pink after 14.2mL of the sodium hydroxide solution had been added.

(a) Write a balanced chemical equation for the reaction that occurred between the calcium carbonate in the tablet and the hydrochloric acid. How many moles of hydrochloric acid were added to the tablet? **2**

(b) Calculate the mass of calcium carbonate in the original antacid tablet. **3**

26. The diagram below shows a coffee cup calorimeter used by a student to measure the enthalpy of neutralisation of an acid-base reaction:



120mL of 0.500molL^{-1} sodium hydroxide was added to 60.0mL of 0.500molL^{-1} sulfuric acid. Both solutions were at a temperature of 24.2°C. After mixing, the final temperature was 26.3°C. **3**

(a) Calculate the enthalpy change per mole of water formed in this reaction

(b) The heat of combustion of a number of alcohols are shown in the table:

i. Using the data provided, construct a graph that shows the relationship between chain length (number of carbon atoms) and the enthalpy of combustion for these alcohols. **3**

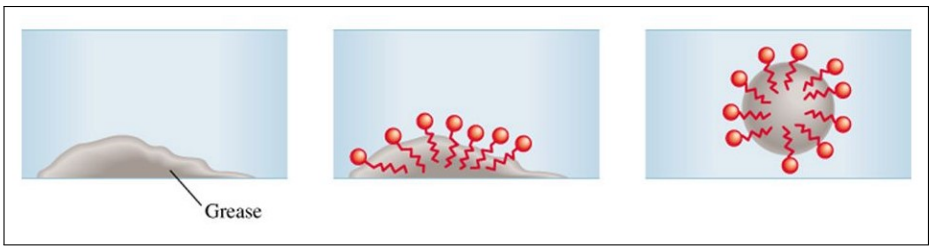
Alcohol	**Heat of Combustion (kJmol^{-1})**
Methanol	-726
Propan-1-ol	-2021
Butan-1-ol	-2676
Pentan-1-ol	-3331
Hexan-1-ol	-3984

ii. Using the graph constructed in (i), predict the value of the enthalpy of combustion of ethanol in kJmol^{-1}. **1**

27.

(a) Soap is one product of saponification. Define saponification. Name the other product and draw its structural formula. **3**

(b) The diagram below shows a sequence of steps in the removal of grease from a surface. Explain the process shown in these steps. **3**



28. An alkane has a molar mass of 72.146 gmol^{-1}. Draw structural formulae for all isomeric molecules that have this molar mass. Name these molecules systematically. **4**

29. A student was supplied with the following chemicals to investigate the equilibrium between yellow chromate ions (CrO_4^{2-}) and orange dichromate ions ($Cr_2O_4^{2-}$) in an aqueous solution. **4**

- Solid potassium dichromate (K_2CrO_4)
- Solid potassium dichromate ($K_2Cr_2O_7$)
- 1M hydrochloric acid
- Distilled water

The equilibrium reaction is: $2\,CrO_{4\,(aq)}^{2-} + 2\,H_{(aq)}^{+} \rightleftharpoons Cr_2O_{7\,(aq)}^{2-} + H_2O_{(l)}$
Describe a series of experiments that the student could perform to investigate the chromate/dichromate equilibrium. Predict the results of these experiments.

30. A haloalkane **A**, of molar mass 137.012 gmol^{-1}, has the following percentage composition:

Element	% Composition
C	35.0
H	6.6
Br	58.4

Hydrolysis of this substance gave compound **B**, which was readily oxidised to a single organic product (Compound **C**).

(a) Construct a flow chart for the production of **C**, showing all the additives and by-products in the process. **5**

(b) Name **A, B** and **C**. **3**

31. Sodium ethanoate is used in the textile industry to neutralise sulfuric acid waste streams.

(a) Write an equation for the formation of sodium ethanoate from and acid-base reaction. Name the reactants. **2**

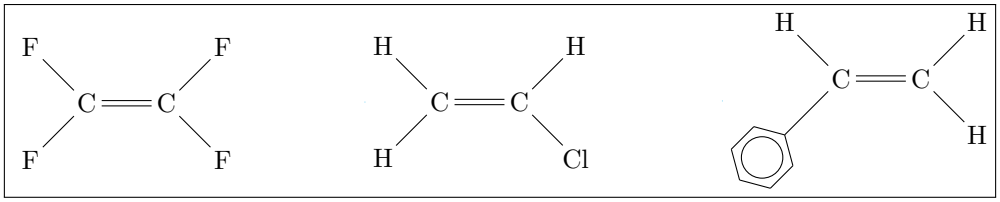
(b) An acid-base reaction is known as neutralisation, yet the resulting salt is not always neutral. Explain the reason for this, including equations to support your answer. **2**

32. Solutions of nitric, ethanoic and sulfuric acids with the same concentrations ($0.0125 \text{mol} \text{L}^{-1}$) have been prepared. The pH of the ethanoic acid is 3.80.

(a) Calculate the pH of the nitric acid solution. **1**

(b) Calculate the pH of the sulfuric acid solution. Compare this pH with the pH of the other acids. Justify your answer. You may assume that both ionisations of sulfuric acid are complete, without needing to consider the K_{A1} value. **3**

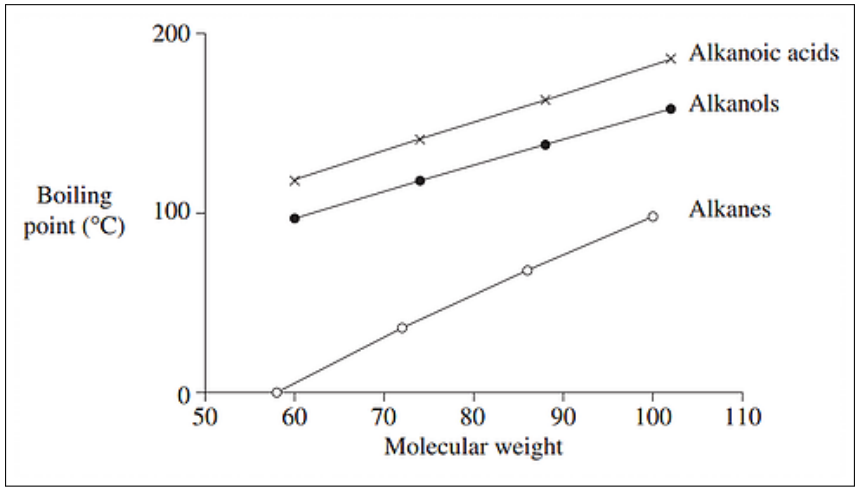
33. The structures of three commercially significant polymers are shown below:



(a) Identify the common name of ONE of the monomers AND draw the structure of a polymer made from the same monomer. **2**

(b) *"The uses of polymers are dependent on their properties."* **3**
Discuss this statement with reference to TWO properties of a polymer made from one of the above monomers. This need not be the same polymer that you drew and named in part (a).

34. Explain the trends in boiling points shown in the graph below. **4**



35. A student used propan-1-ol and ethanoic acid in a reflux reaction to produce an ester. He purified the mixture and obtained what he thought was a very pure sample of the product. The available analytical techniques are Infrared Spectroscopy, ^{13}C NMR, Mass Spectroscopy and UV Visible Spectroscopy. **8**
Justify the technique(s) he should use to confirm the product of the reaction, AND justify which of the above techniques would NOT be helpful in identification of the product. In your answer, draw and name the ester, and provide analysis of expected results from ALL analytical techniques.

A

1	2	3	4	5	6	7	8	9	10	11	12
A	A	D	C	C	B	D	~~D~~	C	A	C	B

13	14	15	16	17	18	19	20
D	~~A~~	A	B	D	D	C	B

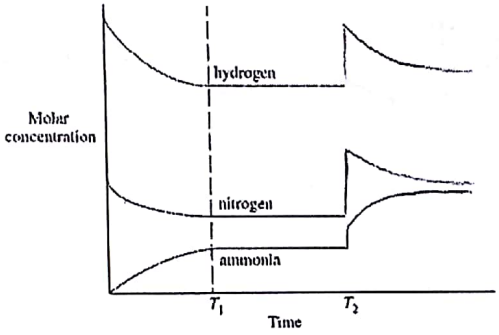
B

Question 21

a)

Criteria	Marks
• Correctly sketches all three trends • Identifies that equilibrium is re-established	2
• All three trends shown correctly	1

Sample answer:



b)

Criteria	Marks
• Outlines how Le Chatelier's principle is applied to trends in the graph • States effect in terms of relative number of moles of gas on either side	2
• States Le Chatelier's principle OR • States that equilibrium is disturbed	1

Sample answer: As volume is reduce, pressure is increased. According to LCP, system will conteract change by favouring reaction that minimises change, therefore will shift to right that has less gas moles than left side.

Question 22 a)

Criteria	Marks
• Provides correct answer and working	3
• Provides substantially correct answer with working	2
• Provides a relevant step	1

Sample answer:

$CaF_{2\,(s)} \leftrightarrows Ca^{2+}_{(aq)} + 2F^-_{(aq)}$

$K_{sp} = [Ca^{2+}]\,[F^-]^2$ Let x = concentration of ions

$x.(2x^2) = 1.00 \times 10^{-11}$

$4x^3 = 1.00 \times 10^{-11}$

$x = 1.36 \times 10^{-4}$ molL^{-1}

Solubility of calcium = solubility of calcium fluoride = 1.36×10^{-4} molL^{-1}

22 b)

Criteria	Marks
• Provides correct Q value and working • States that the system is not at equilibrium • Correctly states the system will favour the reactants or reverse reaction.	3
• One item from above is incorrect or missing	2
• Two items from above are incorrect or missing	1

Sample answer:

$Q = [CS_2]\,[H_2]^4 / [CH_4]\,[H_2S]^2$

$= [0.9]\,[1.78]^4 / [1.07]\,[1.2]^2$

$= 5.86$

Q > K, therefore the system is not at equilibrium and will favour the reactants (or reverse reaction)

Question 23

a)

Criteria	Marks
• Links pressure and temperature changes correctly to change in equilibrium position and describes changes thoroughly (as per sample below) • Correctly identifies impact on K value	3
• Provides substantially correct answer	2
• Provides some relevant information	1

Sample answer:

Decrease in volume (causes increase in pressure)	*Decrease in temperature*
• System adjusts to decrease pressure by Le Chatelier's principle • Equilibrium moves to reactant side as less moles of gas will reduce pressure • No change to K when equilibrium re-established	• Systems adjusts to increase temperature by Le Chatelier's principle • Equilibrium moves to reactant side to produce more heat • K will be lower when the new equilibrium is established

b)

Criteria	Marks
• Provides correct answer to the correct number of significant figures (3) and provides full working – balanced equation, determination of concentration from moles provided, K formula and substitution, correct answer to 3 significant figures	4
• Provides substantially correct working and answer	3
• Provides some relevant steps	2
• Provides a relevant step	1

Sample answer:

$$NH_4HS(s) \rightleftharpoons NH_3(g) + H_2S(g)$$

$$n\ NH_3 = 0.0328 = n\ H_2S$$

$$[NH_3] = [H_2S] = \frac{0.0328}{3}$$

$$= 0.0109$$

$$K = [NH_3][H_2S]$$

$$= 0.0109 \times 0.0109$$

$$= 1.20 \times 10^{-4}$$

Question 24

Question	Marking guide
24	

Criteria	Marks
• Provides definitions of BOTH Arrhenius and Bronsted Lowry theory • Correctly shows why this would not be considered an Arrhenius acid-base reaction • Provides a valid reason this reaction is a Bronsted Lowry Reaction • Includes a relevant equation (balanced and correct states)	4
3 of the above	3
2 of the above	2
Provides some relevant and factually correct information	1

Sample answer:

Arrhenius definition of an acid/base is: acids will release hydrogen ions and bases will release hydroxide ions when dissolved in water. (implies that reaction must take place in aqueous form).

On the other hand a Bronsted Lowry definition of an acid/base is an acid which donates a proton and a base as a proton acceptor.

Therefore the reaction above (HCl (g) + NH3 (g) → NH4Cl (s)) cannot be an Arrhenius acid/base reaction as it is not in aqueous solution and the base does not dissociate to form OH-. The reaction above is a Bronsted Lowry reaction as the reactants are in gaseous phase and the base (NH3) is a proton acceptor.

Question 25 a)

Criteria	Marks
• Writes a correctly balanced equation and includes states of matter ($CaCO_3(aq) + 2HCl \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$) • Correctly calculates the moles of hydrochloric acid (n = 0.015 moles)	2
One of the above	1

25 b)

Criteria	Marks
• Calculates the mass of calcium carbonate and shows working and significant figures and units n_{NaOH} = 0.00142 $n_{HCl\ reacted}$ = 0.015-0.00142=0.01358 m_{CaCO3} = 0.680g	3
• Provides some correct steps in the calculation	2
• Calculates moles of NaOH OR • Writes balanced equation for the reaction of NaOH with HCl or correct mole ratio OR • Calculates molar mass of calcium carbonate	1

Question 26 a)

Criteria	Marks
• Definition of saponification given • Other product (glycerol/ propan-1,2,3-ol) named • Its structural formual given	3
Only 1 or 2 of above points provided	1/2

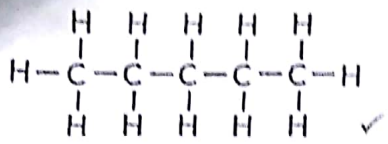
26 b

Criteria	Marks
Thorough explanation of the process linking the structure of the surfactant to its ability to form an emulsion in water with grease. Must include reference to: - Dissolution of soap in water and Grease being non-soluble in water - non-polar tail of soap molecule adsorbing to grease - Charged heads of surfactant form a layer around the grease giving a hydrophilic surface - Through agitation the water penetrates between the grease and the surface causing a droplet to form (micelle) - The grease droplet is held in solution and attracted to the water molecules by anions on the droplet's surface Forms an emulsion and grease is washed away	
Missing 2	**2 marks**
Missing more than two details	**1 mark**

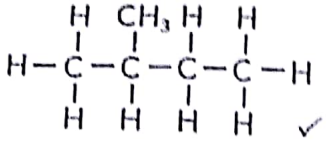
Question 27

Criteria	Mark
• Correct structural formulas for 3 isomers and names of each given **AND** • Calculation to demonstrate that the compound is C_5H_{12}	4
• Correct formulas and names given for C_5H_{12}	2-3
• Some relevant information	1

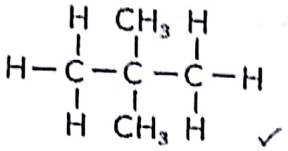
Sample Answer: C_5H_{12}



pentane



methylbutane



dimethylpropane

Question 28 a)

28	***Calculation:*** • *Must use correct equations* • *Answer must be correct units (kJ/mol) and a negative value* • *Equation must be balanced with correct states*

Criteria	**M**
Gives balanced equation *AND* Performs correct the calculation *AND* Give the correct answer	
Gives balanced equation *AND* Performs the correct calculation OR gives the correct answer	
Shows some understanding of the calculation	
GRAPH (b)	
Labels Axes (dependant and independent) AND	

Accurately plots points AND Draws a line of Best fit		
Any of TWO of the above		2
Any ONE of the above		1

(a) $H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$

1 mole of sulfuric acid (a diprotic acid) reacts with 2 moles of alkali to form 2 moles of water.

$2H^+(aq) + 2OH^-(aq) \rightarrow 2H_2O(l)$

moles of water formed = moles of sodium hydroxide

$$= \frac{120}{1000} \times 0.500$$

$$= 0.0600 \text{ mol}$$

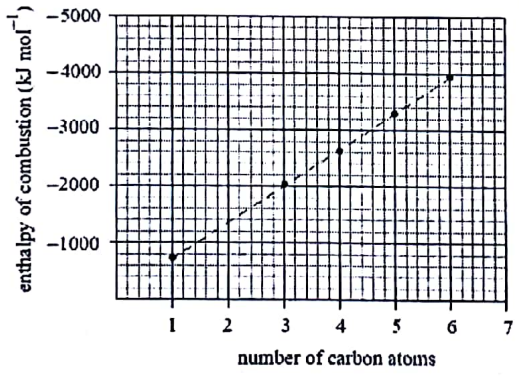
heat change $(q) = mc\Delta T$

$$= \frac{(120 + 60)}{1000} \times 4.18 \times 10^3 \times (26.3 - 24.2)$$

$$= 0.8 \times 4.18 \times 2.1 = 1.58 \text{ kJ}$$

$$\therefore \Delta H = \frac{-q}{n(\text{water})} = \frac{-1.58 \text{ kJ}}{0.06 \text{ mol}} = -26.3 \text{ kJ mol}^{-1} \text{ (exothermic)}$$

(b)



28 b)

- **Range from -1350 – 1450 kj/mol (correct answer and units – 1)**

Question 29

Criteria	Marks
• Correct method of experiment • Correct prediction	4
• Some relevant information	1/2

Sample answer:

Method:

a Prepare 0.1 mol/L aqueous solutions of both salts.

b Place about 3 mL of the yellow potassium chromate solution in a test tube. Add drops of HCl and observe the colour change. Then add water and observe the colour change. ✓

c Place about 3 mL of the orange potassium dichromate solution in a test tube. Add water and observe any colour change. Then add HCl and observe the colour change. ✓

Predictions:

a The addition of HCl leads to an increase in the concentration of H^+. This will promote the forward reaction and the solution will become more orange. When water is added the solution becomes more yellow as the reverse reaction is promoted. ✓

b The addition of water will promote the reverse reaction and the solution will become less orange and more yellow-orange. When HCl is added the solution becomes more orange again as the forward reaction is promoted. ✓

Question 30

Criteria	Marks
• Calculation to determine hydrocarbon formula • Naming hydrocarbon as 2-bromobutane • 2-step flow chart of process • Identification of additives for both processes i.e. H_2O/H^+ and MnO_4^-/H^+ • By products shown	5
• Any 4 of above points only	4
• 3 of the above points	3
• 2 of the above points	2
• Any relevant info	1

b)

Criteria	Marks
Correct names given of A (2-bromobutane), B (2-butanol) and C (butanone)	3
Only 1 or 2 correct	1/2

Question 31

Sample answer

(a) $CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$ **(1)**: Acetic acid and sodium hydroxide **(1).**

Many students did not know the formula for sodium ethanoate. (Some used sodium ethoxide). A few students used the general representation ($C_2H_4O_2$) to represent acetic acid, which in this case is not sufficient to clearly identify the compound as the acid.

No half marks

(b) Following on from above, the salt is **CH_3COONa.** When this salt is dissolved in water, it can hydrolyse:

$$CH_3COONa \rightarrow CH_3COO^- + Na^+$$

Since the anion is a strong conjugate base, it can react with the solvent, water to produce OH- ions:

$$CH_3COO^- + H_2O \rightarrow CH_3COOH + OH^-.$$

The presence of the hydroxide ion, means that this salt is basic. (Acetic acid is a weak acid which means that it prefers the molecular form rather than the ionic form).

A similar argument can be applied to acidic salts such as ammonium chloride.

- **Correct understanding of conjugate acids/bases is clearly explained. (1)**
- **Relevant Equation (1)**

MISCONCEPTIONS:

- Many students talked about the reaction between a strong acid and weak base...**NOT the SALT. (Read The Full Question).**
- Many students **incorrectly asserted** that due to the strong ionisation of the acid, and the weak ionisation of the base (or vice-versa), there was an excess of hydrogen ions making the salt acidic or similar.
- Many students implied a limiting reaction type scenario and failed to recognise the importance of conjugated acid and bases.
- Some students could not identify the correct conjugate base of acetic acid.

31 b)

Criteria	Marks
• Logical and explicit reasoning outlining conjugate acid/base theory correctly with reference to the **SALT AND** • Relevant Equation(s) included in explanation that demonstrate the SALT produces an acidic or basic solution clearly.	2
• Logical and coherent reasoning with no contradictions. OR • Relevant Equation(s) included in explanation that demonstrate the SALT produces an acidic or basic solution clearly.	1

Question 32

Criteria	Marks
• Identifies that nitric acid is a strong acid – equations or stated • Correctly calculates pH of HNO_3 to 3 decimal places	1

Sample answer:

$HNO_3 \rightarrow H^+ + NO_3^-$

0.0125 0.0125 0.0125

$pH = -\log_{10}[H^+] = -\log_{10}[0.0125] = 1.903$

Criteria	Marks
• Correctly calculates pH of sulfuric acid • Identifies that sulphuric acid is diprotic and nitric acid is monoprotic and hence lower pH • Identifies that ethanoic acid is a weak acid and hence higher pH	3
• Correctly calculates pH of sulphuric acid • Identifies that sulphuric acid is diprotic and nitric acid is monoprotic and hence lower pH OR • Identifies that ethanoic acid is a weak acid and hence higher pH	2
• Correctly calculates pH of sulphuric acid OR • Identifies that sulphuric acid is diprotic and nitric acid is monoprotic and hence lower pH OR • Identifies that ethanoic acid is weak acid and hence higher pH	1

Sample answer:

$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$

0.0125 0.0250 0.0125

$pH = -\log_{10}[0.0250] = 1.602$

Acetic acid is a weak acid, ionises partially, low $[H^+]$, higher pH

Nitric acid is strong monoprotic acid and sulphuric acid is a strong diprotic acid.

$[H^+]$ of nitric acid is lower than $[H^+]$ from sulphuric acid. So sulphuric acid had lower pH than nitric acid.

Question 33

a)

3 3	***Name and drawing:*** • *Styrene, vinyl chloride and tertafloroethtene* • *Drawing must be a polymer*

Criteria	M

Correct common name of monomer		1
Correctly drawn structure of a polymer		1

Properties and uses of polymers

Criteria	Marks
• Correctly names polymer from the monomers above, • Explicitly states TWO properties • Application of the stated properties • Discusses why the property allows for the successful (named) use of the named polymer	4
Any 3 of the above	3
Any 2 of the above	2
Any 1 of the above	1

Sample answer:

Polystyrene is a polymer produced from the styrene monomer. This polymer has a large styrene functional group which leads the loosely packed polymer strands (amorphous) and brittle polymer as the strands cannot move freely. Amorphous nature allow for air to be blown, expanding the polymer, changing the property low impact resistance to a high impact and thermal resistance due to the air pockets. These properties then allow polystyrene to be successfully used as packaging/impact resistance (transporting & bike helmets) and insulated cups.

Question 34

Marking guideline:

- Interhomologous trend for similar molecular weights are identified and explained (2)
- Intrahomologous trend identified and explained (1) – linear trend
- Different gradient identified and explained. (1)

Mark(s) not awarded if confusion between forces and bonds is evident.

Sample answer

For all homologous series shown, there is an increase in boiling point as the chain length increases. This can be attributed to the inclusion of a CH_2 unit, which provides more electrons that contribute to the overall dispersion forces that act between molecules. These forces need to be overcome to turn the liquid into a gas. Thus, increasing molecular weight corresponds to an increase in boiling point.

It should be noted from the graph that the gradient for each homologous series is different. The increase in boiling point per CH_2 unit is greater for alkanes than for alkanols and alkanoic acids. A possible reason for this would be the interference experienced between molecules by the chain growth, diminishing the impact of extra electrons (and mass) in alkanols and alkanoic acids.

The difference in boiling points between the groups for molecules of similar weight are directly attributed to the presence of the functional group in alkanols and alkanoic acids. The hydroxyl and carbonyl groups allow for hydrogen bonding between molecules, which contribute significantly to the intermolecular force in comparison to the alkanes. Alkanoic acids have a higher boiling point than alkanols because it is able to offer more sites for hydrogen bonding, has greater dispersion forces (extra oxygen atom with 8 electrons) and can form stable dimers.

Common misconceptions/errors encountered in Students responses:

- Improper use of the terms "forces" and "Bonds" leading to the grave misconception, and very poor expression, that 'bonds need to be broken' when boiled. We are not breaking apart the molecule. Use correct **METALANGUAGE**.
- "Carbon-hydrogen" or "carbon-carbon bond" is responsible for dispersion forces.
- Oxygen-hydrogen (hydroxyl) group contains hydrogen bond
- Water is involved in the process of determining boiling point of organic compounds.

Weaknesses

- Not referencing that comparison between alkanes, alcohols and alkanoic acids are for similar molecular weights.
- Very few students identified correctly that intermolecular forces are broken in the phase change between liquid to gas.
- Significant lack of clarity in use of terminology.

Question 35

Criteria	Marks
• Name the ester and possible impurities • Describe FOUR methods thoroughly and justify • Answer coherent	8
• Name the ester and possible impurities • Describes any THREE methods thoroughly and justify • Describes one method not thoroughly • Answer coherent	7
• Name the ester • Describe ONE useful method thoroughly • Describe ONE method nor useful thoroughly • Justify the methods used	6
• Name the ester • Describe any TWO methods thoroughly • Justify one method • OR • Identify 4 methods + one justification	5
• Name the ester • Describe ONE method thoroughly + justify • OR • Identify THREE methods	4
• Identify FOUR methods	3
• Identify 2-3 methods	2
• Identify 1-2 methods	1

Model Answer:

The ester produced is propylethanoate. Impurities present could be unreacted propan-1-ol, unreacted ethanoic acid.

Three methods that could be helpful to identify the purity of the sample include: IR spec, C13 NMR and Mass Spec. UV Vis will be the least helpful technique.

1. IR spec is useful as it helps to identify the functional groups present in the sample. The graph of a pure sample will show absorption due to

   C - C at 750 – 1100cm^{-1}
   C - O at 1000 – 1300 cm^{-1}
   C = O at 1680 – 1750 cm
   If impurities are present, then O – H (alcohol) will show absorption at 3230 – 3500 cm^{-1} and O – H (acid) AT 2500 – 3000 cm^{-1} would also show up.

2. C13 NMR is useful in confirming the number of carbon environments. Propylethanoate has 5 carbon environments so a pure sample will show 5 lines:

   O
   R – C - at 160 – 185 ∂/ppm

- C – O at 50 – 90 ∂/ppm
- C – C at 5 – 40 ∂/ppm

- Judging by the intensity of the peaks, the products can be identified. Impurities will produce other peaks at various values.

3. Mass spectroscopy is useful in confirming the molecular mass of the ester produced (102.05g/mol). Other peaks will also be seen because of the fragments produced. This can be compared to graph of established pure ester. Impurities will produce other molecular masses corresponding to propan-1-ol and ethanoic acid. There are other esters with a mass of 102.05. To confirm that the ester is propylethanoate, other significant peaks at m/z = 43 will signify the presence of a propyl group.

4. UV/Vis will be the least helpful technique in confirming the purity of the product as this will only give information on the λ_{max} which cannot be used to identify the ester. It can identify relevant chromophores present but that is not useful on its own. UV/Vis spectra is useful in identifying molecules with conjugate double bonds (chromophores) which absorb in the visible region of a particular λ_{max} in the visible region.