
Student Number

CHELTENHAM GIRLS HIGH SCHOOL

2020

High School Certificate
TRIAL EXAMINATION

CHEMISTRY

General Instructions	**Total marks - 100**
• Reading time – 5 minutes • Working time – 180 minutes • Write using **black pen** only • Draw diagrams using pencil • Use the multiple-choice answer sheet provided • NESA-approved calculators may be used • Write your Student Number at the top of this page and on the multiple-choice answer sheet write BOTH your number AND name	Section I - 20 marks (pages 1 - 6) • Attempt Questions 1-20 • Allow about 30 minutes for this section Section II - 80 marks (pages 7 - 22) • Attempt Questions 21- 36 • Allow about 2 hours and 25 minutes for this section

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

Use the multiple-choice answer sheet for Question 1 - 20

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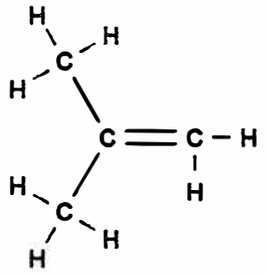
1. What is the correct IUPAC name for the following compound



   A. 2-methenpropane
   B. 2,2-dimethylethene
   C. 2-methylpropene
   D. 2-methylprop-2-ene

2. 300 mL of hydrochloric acid with pH 2.1 is mixed with 500mL of sulfuric acid with pH 3.5. Assuming that the two acids do not react with each other and that both acids were fully dissociated, find the concentration of protons in the newly mixed solution.

   A. 3.2×10^{-3} M
   B. 8.3×10^{-3} M
   C. 1.0×10^{-2} M
   D. 2.5×10^{-3} M

3. By using Le Chatelier's principle, which of the following statements can be concluded in regards to the carbon dioxide equilibrium in soft drinks?

   A. Adding a base to soft drinks will increase the solubility of carbon dioxide.
   B. Carbon dioxide is only more soluble in water than oxygen under acidic conditions.
   C. The equilibrium will shift to favour the release of carbon dioxide if the temperature is lowered.
   D. The effect of a disturbance cannot be predicted without knowing the actual amount of carbon dioxide in soft drinks.

4. An alkane was placed in a solution of bromine water. Under what conditions will the alkane undergo an addition reaction?

   A. Alkanes will not undergo addition reactions.
   B. When bromine water is heated.
   C. When an alkene is also present in the mixture.
   D. In the presence of UV light for prolonged periods.

5. Benzoic acid ($C_6H_5CO_2H$) is a monoprotic acid with a $pK_a = 4.2$. What is the pH of a 0.40 M solution of benzoic acid?

   A. 1.3
   B. 2.3
   C. 5.0×10^{-3}
   D. 5.0×10^{-2}

6. Which of the following relationships are true.

   A. A strong acid has high pK_a
   B. A weak acid has low pK_a
   C. A strong acid has low pK_a
   D. A concentrated acid has low pK_a

7. The following shows the equilibrium reaction between hydrogen and sulfur dioxide.

   $$2H_{2(g)} + SO_{2(g)} \rightleftharpoons S_{(s)} + 2H_2O_{(g)}$$

   Which of the following will shift the equilibrium to the right?

   A. Increasing the volume
   B. Removal of water
   C. Removal of sulfur
   D. Decreasing the pressure

8. Which of the following will only produce ONE distinct product following an addition reaction with HCl.

   A. But-1-ene
   B. But-3-ene
   C. Pent-2-ene
   D. Hex-3-ene

9. The chemical equation for the precipitation of chromium hydroxide is shown below:

$$Cr^{3+}_{(aq)} + 3OH^{-}_{(aq)} \rightleftharpoons Cr(OH)_{3(s)}$$

Which one of the below is the equilibrium expression for the precipitation of chromium hydroxide?

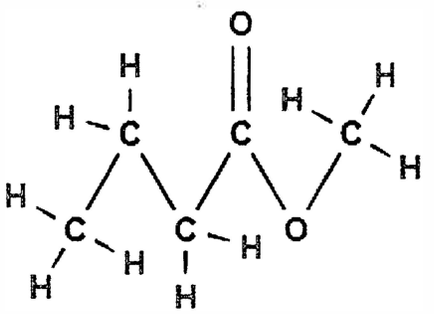
A. $$K_{eq} = \frac{3[Cr(OH)_3]}{[Cr^{3+}]\,3[OH^{-1}]}$$

B. $$K_{eq} = \frac{[Cr(OH)_3]}{[Cr^{3+}][OH^{-1}]^3}$$

C. $$K_{eq} = \frac{1}{[Cr^{3+}][OH^{-1}]^3}$$

D. $$K_{eq} = \frac{1}{[Cr^{3+}]\,3[OH^{-1}]}$$

10. What is the name of the following ester and the reagents needed to make it?



Answer	Name	Reagents
A	Methyl butanoate	Butanol + Methanoic acid
B	Butyl methanoate	Butanol + Methanoic acid
C	Butyl methanoate	Methanol + Butanoic acid
D	Methyl butanoate	Methanol + Butanoic acid

11. Which of the following substances would you expect to have the highest boiling point?

A. Pentane
B. Butanamine
C. Butanamide
D. Butanol

12. Which of the following solutions has the greatest buffering capacity?

Solution W: A 1.0 M solution of sulfuric acid and sulfate ions
Solution X: A 0.10 M solution of ammonia and ammonium
Solution Y: A 0.10 M solution of acetic acid and acetate
Solution Z: A 1.0 M solution of ammonia and ammonium

A. Solution W
B. Solution X
C. Solution Y
D. Solution Z

13. Which of the following reactions will produce a carboxylic acid?

A. Mixing sugar solution with yeast in the absence of oxygen.
B. Oxidation of primary alcohol.
C. The reaction between alkene and water.
D. Nucleophilic substitution of haloalkane.

14. Calcium hydroxide dissolves in water and has a $K_{sp} = 5.5 \times 10^{-6}$. Calculate the solubility in $molL^{-1}$.

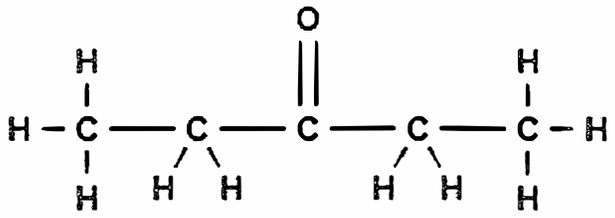
A. $1.1 \times 10^{-2}\ molL^{-1}$
B. $1.8 \times 10^{-2}\ molL^{-1}$
C. $2.8 \times 10^{-6}\ molL^{-1}$
D. $2.3 \times 10^{-3}\ molL^{-1}$

15. Which of the following statements describes if a reaction can be a reversible reaction?

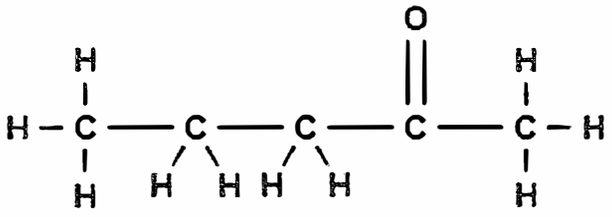
A. If the activation energies of both forward and reverse reaction are high.
B. If the activation energies of both forward and reverse reactions are low.
C. If the activation energy of the exothermic reaction is high and the endothermic is low.
D. If the activation energy of the endothermic reaction is high and the exothermic reaction low.

16. Which of the following is a functional group isomer of pentan-3-one?

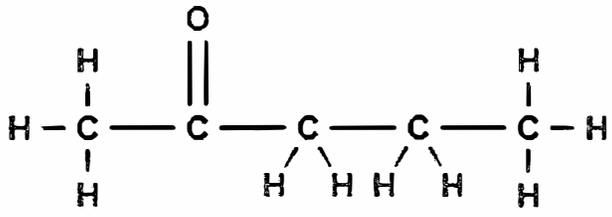
A.



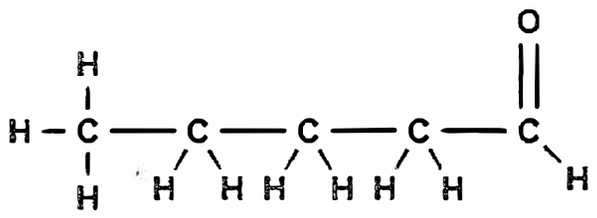
B.



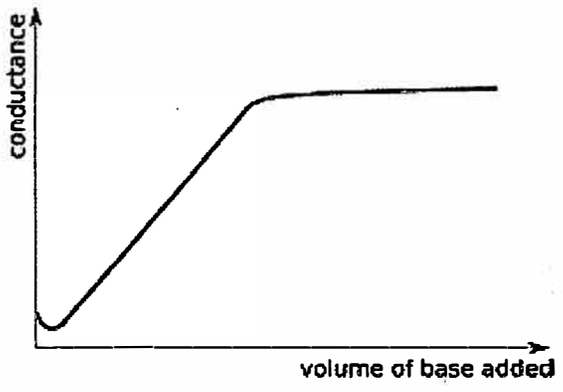
C.



D.



17. A conductometric titration was performed with an acid and a base and the following graph was produced. Which of the following reactions is likely to produce such a graph?



A. $HCl + NaOH$
B. $HCl + NaHCO_3$
C. $CH_3COOH + NaHCO_3$
D. $CH_3COOH + NaOH$

18. Consider the following substances:

I. $H_2PO_4^-$
II. HNO_3
III. NH_4^+
IV. HSO_4^-

Which of these substances are amphiprotic?

A. I only.
B. I and II
C. II and III
D. I and IV

19. The ions which would react to produce a precipitate are:

A. Ca^{2+} and SO_4^{2-}
B. NH_4^+ and CO_3^{2-}
C. K^+ and PO_4^{3-}
D. Ba^{2+} and NO_3^-

20. Which of the following substances has the highest solubility in water.

A. Propanol
B. Methyl methanoate
C. Octanol
D. Butane

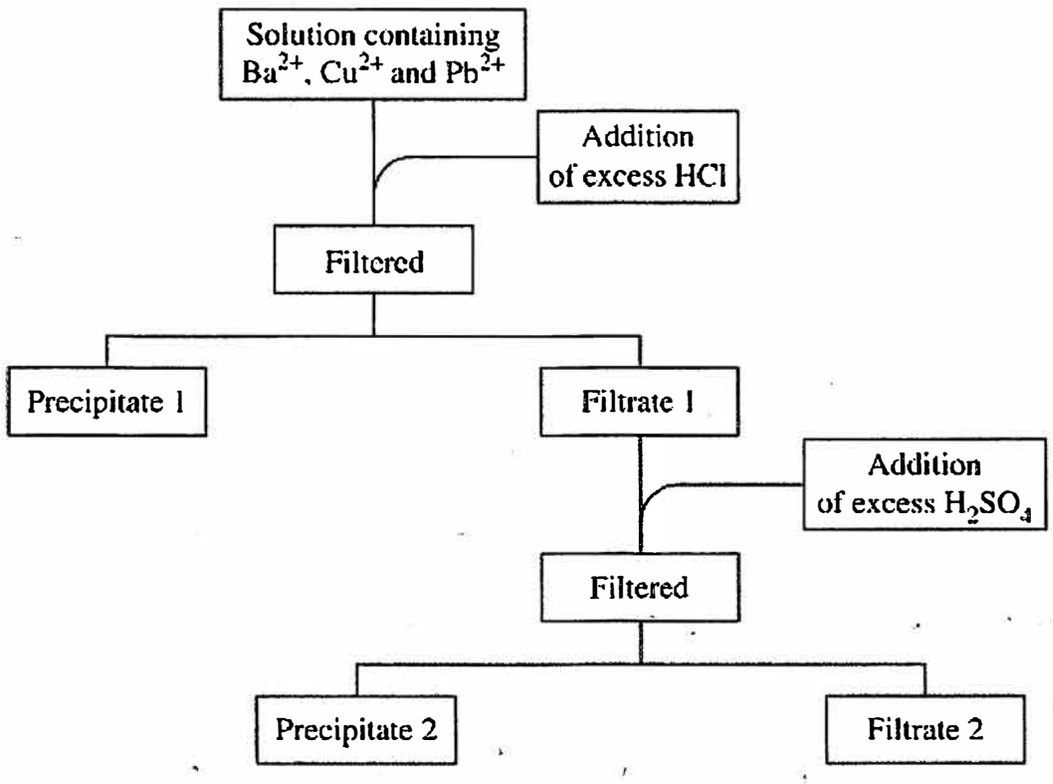
Section II - 80 marks
Attempt Questions 21–34
Allow about 2 hours and 25 minutes for this section

Question 21 (5 marks)

Buffers play an important role in maintaining the pH of natural systems. Using equations, explain how buffers are able to maintain the pH of natural systems even if a strong acid or base is added.

Question 22 (5 marks)

A solution contains three cations, Ba^{2+}, Cu^{2+} and Pb^{2+}. The flow chart indicates the plan used to confirm the identity of these cations.



(a) Name Precipitate 2 (1 mark)

(b) Write a balanced net ionic equation for the formation of Precipitate 1 (2 marks)

(c) Suggest a test and the expected result that would confirm the identity of the metal cation remaining in filtrate 2. (2 marks)

Question 23 (5 marks)

Assess ethanol as a viable alternative to fossil fuels.

Question 24 (3 marks)

Draw and name three isomers of $C_3H_6O_2$.

Question 25 (5 marks)

The K_{sp} of lead (II) chloride is 1.7×10^{-5}.
20.0g of pure solid lead (II) chloride was placed in a 750 mL volumetric flask and distilled water was used to fill up to the calibration mark. Determine if a precipitate was formed and if a precipitate was formed, calculate the mass of the precipitate. Include an equation in your answer.

Question 26 (4 marks)
Calculate the concentration in ppm of Ag_2CrO_4 that will dissolve in 2.00 L of 0.020 M K_2CrO_4 solution. Where the K_{sp} for Ag_2CrO_4 = 9.0 x 10^{-12}.

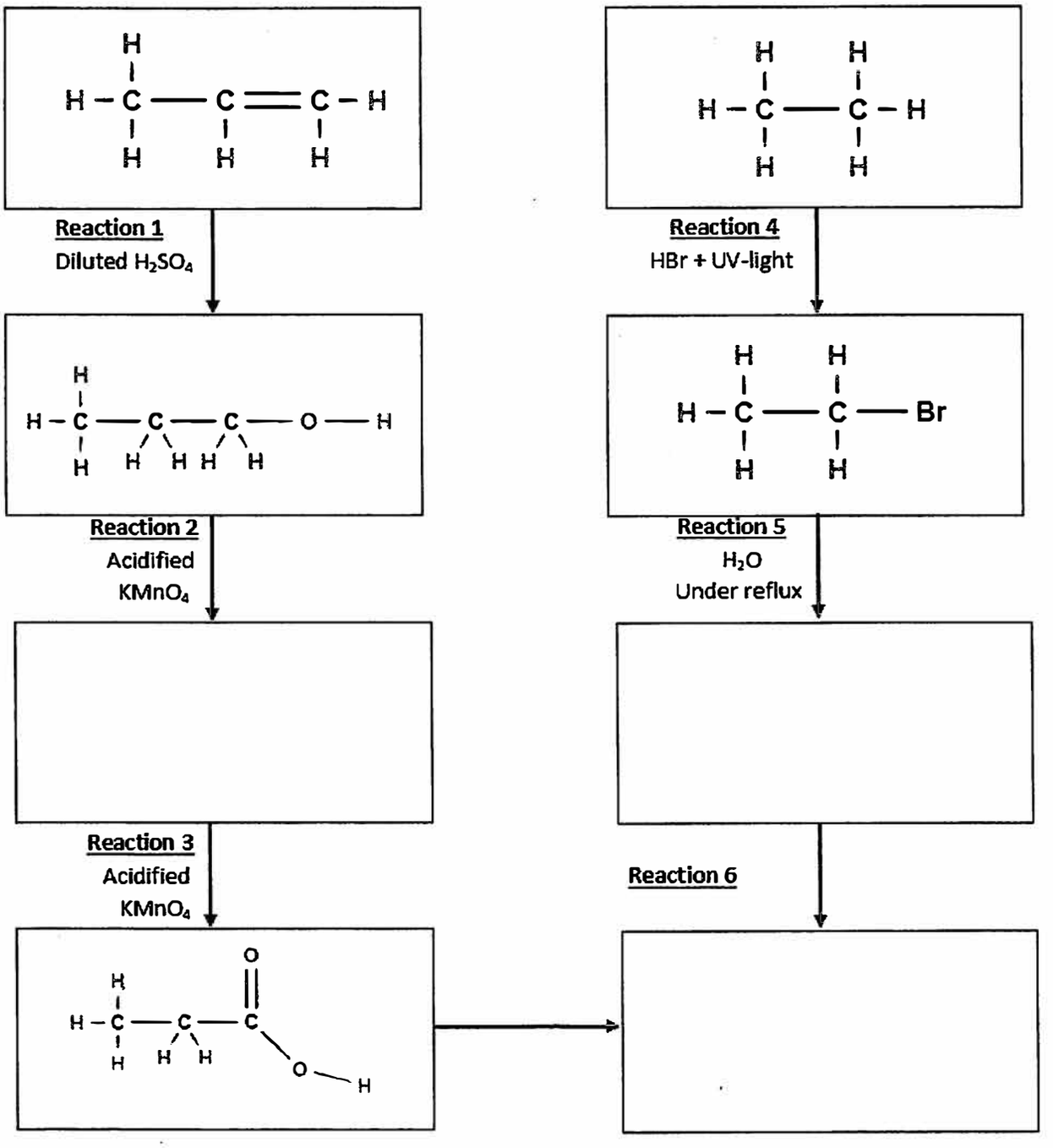
Question 27 (3 marks)
Nitrosyl chloride (NOCl) decomposes into nitrogen oxide and chloride gas in the following equilibrium.

$$2NOCl_{(g)} \leftrightharpoons 2NO_{(g)} + Cl_{2(g)}$$

Calculate the concentration of nitrogen oxide produced in the reaction when 171g of nitrosyl chloride is placed in a sealed 2.50L container.
The K_{eq} of the reaction is 2.5 x 10^{-6}

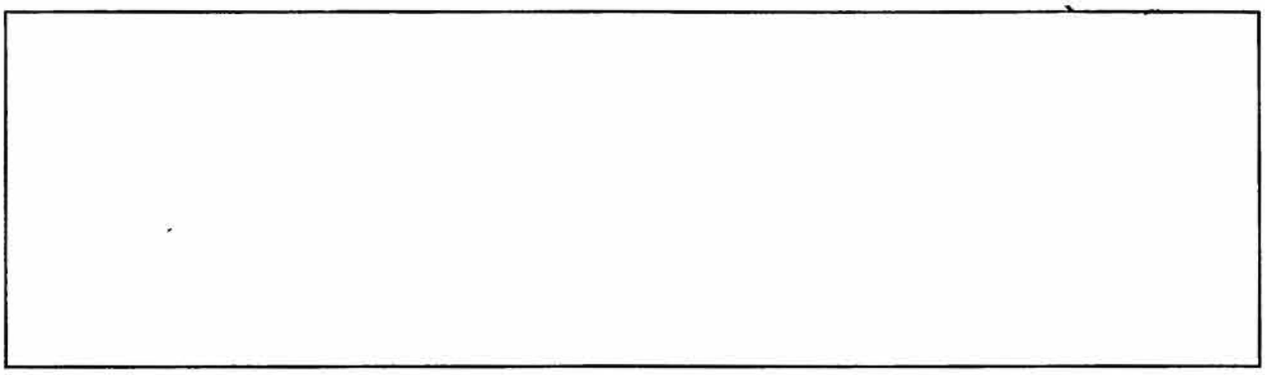
Question 28 (7 marks)

Use the flow diagram below to answer the following questions:



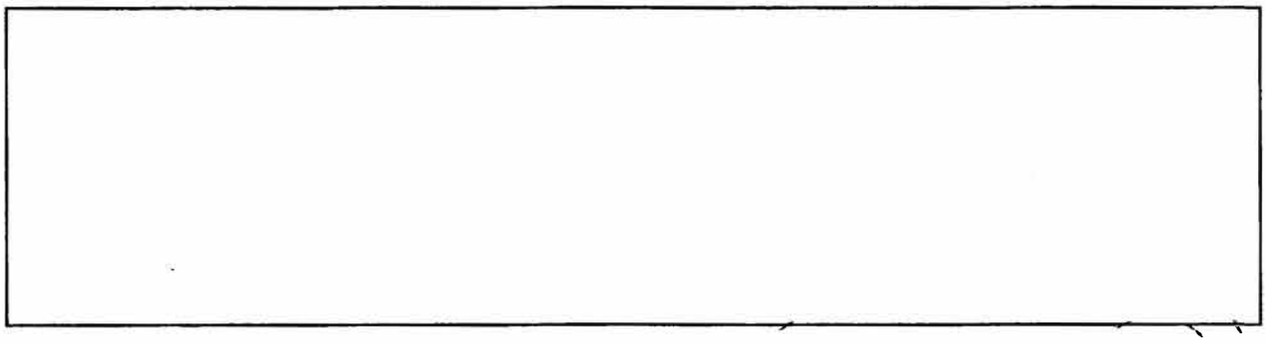
(a) Name and draw the structural formula for the compound produced in reaction 2

(2 marks)



(b) Name and draw the structural formula for the compound produced in reaction 5

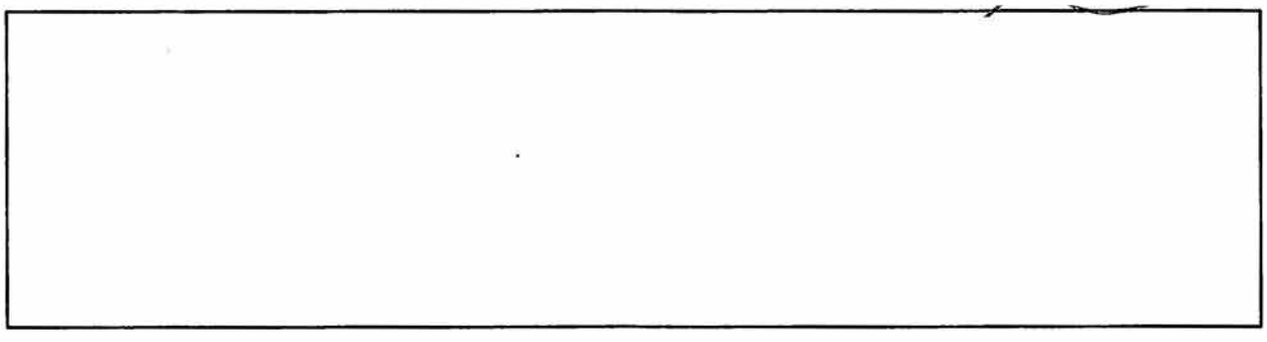
(2 marks)



(c) Identify the type of reaction in reaction 6 (1 mark)

(d) Name and draw the structural formula for the compound produced in reaction 6

(2 marks)



Question 29 (4 marks)

A calorimetry experiment was performed by placing 100.0 mL of distilled water in a 20.0 g copper calorimeter. Ethanol was combusted in a spirit burner to heat the water and the calorimeter. It was found that 70% of the energy was lost to the environment during the experiment.

Calculate the volume of ethanol combusted to to heat the water and the calorimeter by 10.0K

Molar heat of combustion of ethanol = 1370 $kJmol^{-1}$
Specific heat capacity of copper = 0.385 $Jg^{-1}K^{-1}$
Density of ethanol = 0.789 gmL^{-1}

Question 30 (4 marks)

Two solutions were made up and used in a neutralisation reaction.
Solution A: 20 mL of 0.5 M H_2SO_4
Solution B: 30 mL of 0.8 M NaOH

(a) Write the balanced chemical equation for the reaction between solution A and B (1 mark)

(b) Solution A and Solution B were mixed together in a beaker. Calculate the pH of the solution. (3 marks)

Question 31 (4 marks)

A student mixed two solutions of barium chloride and sodium sulfate together. She observed that a precipitate has formed.

(a) Identify the precipitate and write a balanced chemical equation of the reaction. (1 marks)

(b) If the mass of the precipitate formed was 1.37g, calculate the initial mass of the barium chloride present in the solution. (2 marks)

(c) The student read on the label of the barium chloride solution that there were 14.35g of solution in the bottle. Calculate the %(w/w) of barium chloride in this solution.

(1 mark)

Question 32 (6 marks)

Aspirin ($CH_3COOC_6H_4COOH$) is a drug commonly used for pain relief. A student wants to determine the amount of aspirin in a tablet. This is the procedure she followed:

1. A 7.00g tablet containing aspirin was grounded to a powder and placed in a 250.0 mL volumetric flask. The flask was filled with distilled water up to the calibration mark to allow for the aspirin to dissolve.
2. 100.0 mL of this solution was pipette into another clean 250.0 mL volumetric flask. Distilled water was used to fill this volumetric flask up to the calibration mark to dilute the solution.
3. 25.0 mL of the diluted solution is placed in a conical flask and 30.0 mL of 0.10 M NaOH solution was added to the flask. The following reaction occurred:

$$CH_3COOC_6H_4COOH_{(aq)} + 2NaOH_{(aq)} \rightarrow CH_3COO.Na_{(aq)} + HOC_6H_4COO.Na_{(aq)} + H_2O_{(l)}$$

4. This solution was then titrated with 0.10M HCl.

It was found that 18.9 mL of HCl was required to reach the equivalence point.

(a) Identify an indicator that is suitable for the titration. (1 mark)

(b) Calculate the moles of excess NaOH. (1 mark)

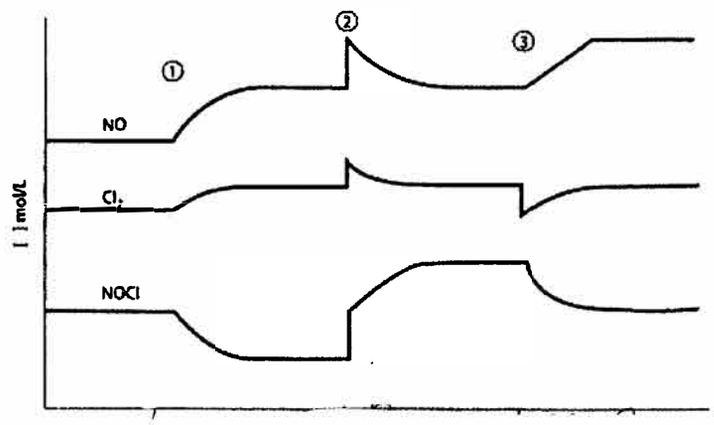
(c) Calculate the moles of NaOH which reacted with the aspirin (1 marks)

(d) Calculate the mass of aspirin in the tablet. (3 marks)

Question 33 (6 marks)

The following graph shows the concentration against time of an equilibrium system.
The reaction is:

$$2NO_{(g)} + Cl_{2(g)} \rightleftharpoons 2NOCl_{(g)} \qquad \Delta H = -261.68\ Jmol^{-1}$$



For each numbered time (1), (2) and (3). Describe what has occurred and explain why the graph

Question 34 (6 marks)

(a) Soap can be produced through the process of saponification. Using a word equation, outline the production of a soap. (3 marks)

(b) Soap acts as an emulsifier, account for the cleaning action of soap. (3 marks)

Question 35 (8 marks)

Below are the pK_{a1} and concentration of three acids solutions

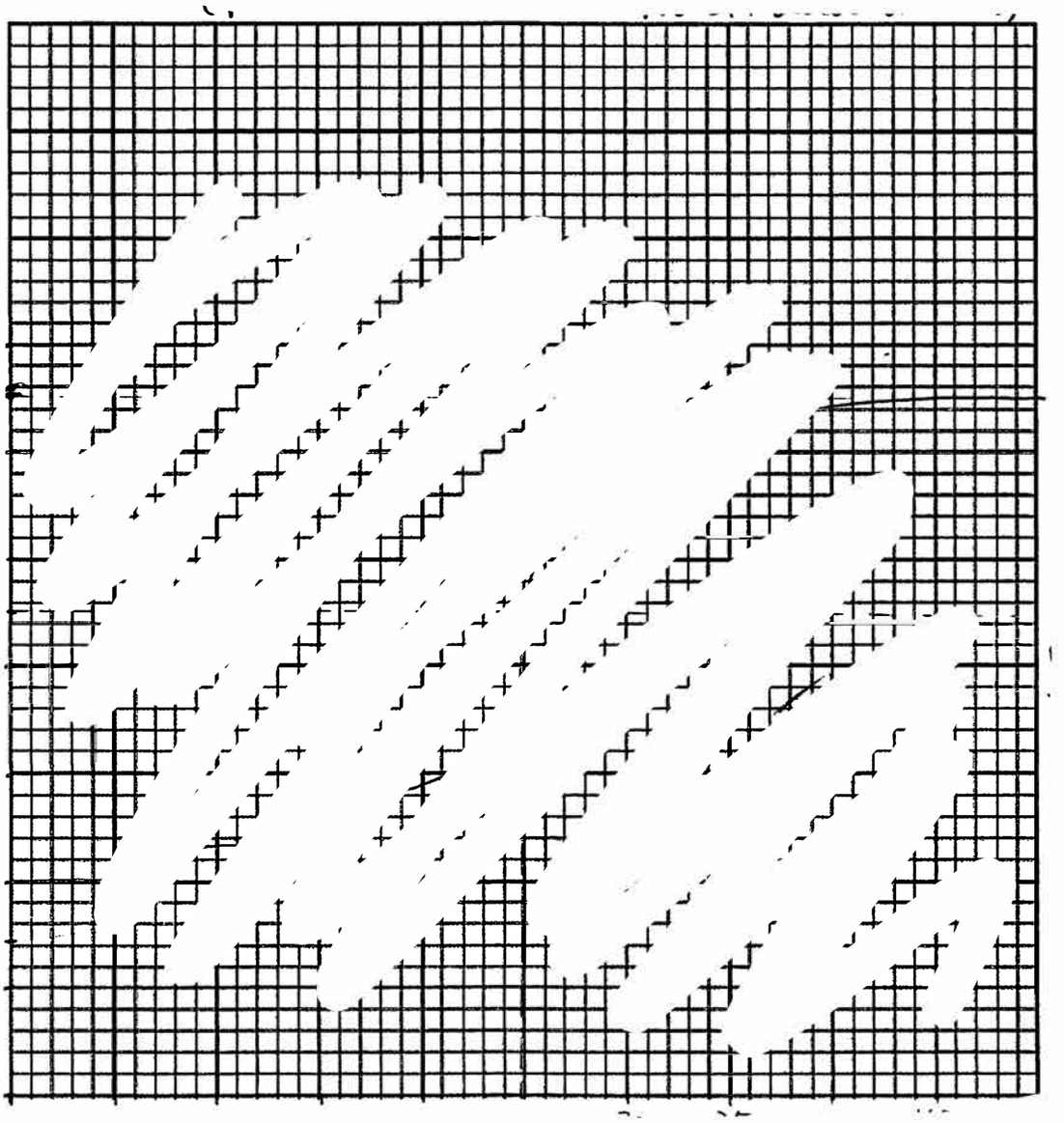
Acids	pK_{a1}	Concentration (M)
HCl	-6.31	0.1
H_2CO_3	6.35	0.1
CH_3COOH	4.76	0.1

(a) Define the terms strength and concentration of acids. (2 marks)

(b) Rank the three acids from the strongest to the weakest, explain your reasoning behind your ranking. (2 marks)

(c) A titration was performed with a 0.1 M NaOH solution against the three acids. Using the data above, rank the acids which required the most NaOH solution to the least NaOH solution. explain your reasoning behind your ranking. (2 marks)

(d) For the titration between CH_3COOH and NaOH. The student placed the CH_3COOH in the conical flask and it was found that 25 mL of NaOH solution was used to reach the equilibrium point. Sketch a titration curve in the graph paper below. (2 marks)



Question 36 (5 marks)

The following reaction shows the decomposition of copper hydroxide.

$$Cu(OH)_{2(s)} \rightarrow CuO_{(s)} + H_2O_{(g)}$$

	$Cu(OH)_{2(s)}$	$CuO_{(s)}$	$H_2O_{(g)}$
Enthalpy of formation ($kJmol^{-1}$)	-450	-157	-242
Standard molar entropy ($JK^{-1}mol^{-1}$)	108	43	189

(a) Using the information above, calculate the Gibbs Free energy change at 500 K.
(3 marks)

(b) From your answer in part (a), state if the reaction is spontaneous at 500 K.
(1 mark)

(c) Calculate the temperature at which the reaction is at equilibrium. (1 mark)

2020 Yr 12 Chemistry Trial Marking Criteria

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
C	A	A	A	B	C	B	D	C	D

Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
C	D	B	A	B	D	C	D	A	A

Question 21

Marking Criteria	Marks
Define buffers and thoroughly explain the principles behind how the buffer works Providing examples of buffer in a natural system including balanced chemical equations.	5
Define buffers and explain in great details the principles behind how the buffer works Providing examples of buffer in a natural system including balanced chemical equations.	4
Define buffers and explain sufficiently the principles behind how the buffer works Providing examples of buffer in a natural system including balanced chemical equations.	3
Define buffers and explain sufficiently the principles behind how the buffer works Providing examples of buffer in a natural system with no equations	2
Define buffers in natural systems.	1

Sample Answer

Buffers are solutions of weak acids and their conjugates, a buffer is able to neutralise any foreign acids and bases that are added to a system without a significant change to pH.

Buffers work under Le Chatelier's principle where any external changes to an equilibrium system will be counteracted by the shift in the equilibrium. In the case where acid is added, the equilibrium will shift to neutralise the acid.

Buffers are vital for the maintenance of pH in the natural environment. For example in waterways where aquatic species lives, a significant change in pH can have drastic effects on the organisms.

In rivers and lakes, the buffer system is composed of dissolved carbon dioxide that reacts with water to form carbonic acid. The carbonic acid is a diprotic acid that can donate two protons

$CO_{2(g)} + H_2O_{(l)} \rightleftharpoons H_2CO_{3(aq)} \rightleftharpoons HCO_3^-{}_{(aq)} + H^+{}_{(aq)} \rightleftharpoons CO_3^{2-}{}_{(aq)} + H^+{}_{(aq)}$

When acids are added to the water, the equilibrium will shift to the left to remove the H^+ ions.

When bases are added to the water, the equilibrium will shift to the right to increase the H^+ ions.

Question 22 (a)

Marking Criteria	Marks
Identify the name of precipitate 2	1

Sample Answer
Barium Sulfate

Question 22 (b)

Marking Criteria	Marks
Provides a correct, balanced net ionic equation	2
Provides a partially correct net ionic equation	1

Sample Answer
$Pb^{2+}_{(aq)} + 2Cl^{-}_{(aq)} \rightarrow PbCl_{2(s)}$

Question 22 (c)

Marking Criteria	Marks
Suggest a suitable test AND Provides the observation expected	2
Suggest a suitable test OR Provides the observation expected	1

Sample Answer
The remaining metal ion is Cu^{2+} which can be tested by a flame test. When present Cu^{2+} copper will turn the flame blue-green.
Answers could include:
Tests for Pb^{2+} or Ba^{2+} if answers to (a) and (b) have been incorrect
Other possible tests for Cu^{2+}, with their positive results.

Question 23

Marking Criteria	Marks
Makes a valid judgement of ethanol as the alternative to fossil fuel with many detailed arguments for AND against its use.	5
Makes a valid judgement of ethanol as the alternative to fossil fuel with some arguments for AND against its use.	4
Makes a valid judgement of ethanol as the alternative to fossil fuel with few arguments for AND against its use.	3
Makes a valid judgement of ethanol as the alternative to fossil fuel with some arguments for OR against its use.	2
Makes a valid judgement of ethanol as the alternative to fossil fuel	1

Sample Answer

Ethanol can be considered an alternative to fossil fuel as it can combust with oxygen to release energy and can therefore be used in various combustion engines.
Ethanol has many advantages over conventional fossil fuels such as octane because it is renewable. This is because ethanol can be produced by the fermentation and distillation of glucose which can be found by various agricultural crops. This means that new crops can be grown every season for the production of ethanol.
Ethanol production is also carbon-neutral, as plants get their carbon content from the carbon dioxide in the atmosphere. The carbon dioxide released from the combustion of ethanol is reabsorbed by the crops. Therefore there is no net gain in carbon dioxide in the atmosphere.
There are also drawbacks from using ethanol as a fuel.
The production of ethanol requires a significant amount of land which would have otherwise been used for growing food. This can have an impact on the population's access to food.
The usage of 100% ethanol in cars will also require investment to modify the engine as ethanol is a much more reactive substance compared to octane. Ethanol also gives less energy per unit volume, which means that an ethanol vehicle will need to refuel more often.
Over ethanol is a viable alternative to fossil fuel due to the significant impact on reducing the greenhouse effect.

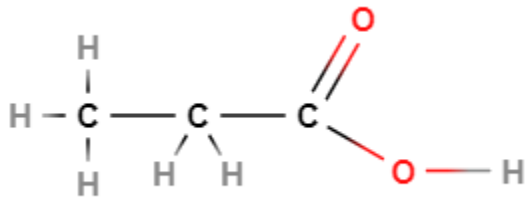
Question 24

Marking Criteria	Marks

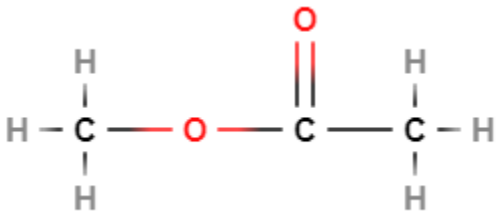
Draw and name THREE isomers of $C_3H_6O_2$	3
Draw and name TWO isomers of $C_3H_6O_2$	4
Draw and name ONE isomer of $C_3H_6O_2$	3

Sample Answer

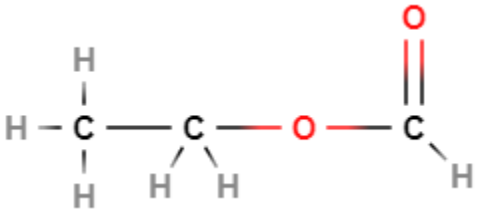
Butanoic acid



Methyl ethanoate



Ethyl methanoate



Question 25

Marking Criteria	Marks
Correctly state that a precipitate was formed and calculate the mass of the lead (II) chloride precipitated. The answer has an equation for the dissociation of lead (II) chloride including states Round the answer to the correct number of significant figures	5
Correctly state that a precipitate was formed and able to calculate the mass of lead (II) chloride precipitated. The answer has an equation for the dissociation of lead (II) chloride including states	4
Correctly state that a precipitate was formed and able to calculate the moles of lead (II) chloride AND the moles of lead (II) chloride that are soluble	3
Correctly state that a precipitate was formed and able to calculate the moles of lead (II) chloride OR the moles of lead (II) chloride that are soluble	2
Correctly state that a precipitate was formed but unable to show any	1

mathematical calculations to prove this.	

Sample Answer

Moles of lead (II) chloride = 20 / 278.1

Moles of lead (II) chloride = 0.071916…

$PbCl_{2(s)} \rightleftharpoons Pb^{2+}_{(aq)} + 2Cl^{-}_{(aq)}$

$K_{sp} = x(2x)^2$ where x is the solubility of lead (II) chloride

$1.7 \times 10^{-5} = 4x^3$

$x = 0.016198…$

Moles of lead (II) chloride soluble in 750 mL = 0.0121485…

Moles of lead (II) chloride is greater than the amount soluble. Therefore a precipitate is formed

Moles of lead (II) chloride precipitated = 0.071916… - 0.0121485…

Moles of lead (II) chloride precipitated = 0.059768…

Mass of lead (II) chloride precipitated = 0.059768… x 278.1

Mass of lead (II) chloride precipitated = 16.62148…

Mass of lead (II) chloride precipitated = 17 g (2 sig fig)

Question 26

Marking Criteria	Marks
Correctly calculate the concentration of soluble Ag_2CrO_4, in ppm, showing equation for the dissociation of Ag_2CrO_4	4
Correctly calculate the concentration of soluble Ag_2CrO_4 in other units, showing equation for the dissociation of Ag_2CrO_4	3
Correctly calculate the concentration of soluble Ag_2CrO_4 in other units.	2
Correctly determine the calculation involves the common ion effect.	1

Sample Answer

Common ion between Ag_2CrO_4 and K_2CrO_4 is the CrO_4^{2-}

Conc of CrO_4^{2-} from the K_2CrO_4 solution = 0.020 M

$Ag_2CrO_{4(s)} \rightleftharpoons 2Ag^{+}_{(aq)} + CrO_4^{2-}_{(aq)}$

$9.0 \times 10^{-12} = (2x)^2 (0.02)$ where x is the concentration of Ag_2CrO_4

$x = 0.0000106066…$ M

$x = 0.003519527… gL^{-1}$

$x = 3.51927...$ ppm rounded to 3.5ppm (2 sig fig)

Question 27

Marking Criteria	Marks
Correctly calculate the concentration of NO gas	3
Correct K formula using values of concentration for each reactant and products	2
Correct K formula but incorrect calculations	1

Sample Answer
Moles of NOCl = 171 / 65.46
Moles of NOCl = 2.6122…
Conc of NOCl = 2.6122… ÷ 2.50
Conc of NOCl = 1.0449...

	c(NOCl)	c(NO)	c(Cl_2)
Initial	1.0449	0	0
Change	1.0449 - 2x	+2x	+x
Equilibrium	1.0449	2x	x

Assume that x is very small compared to 1.0449.. Therefore we can round to zero.

$$K = \frac{(2x)^2(x)}{1.0449^2}$$

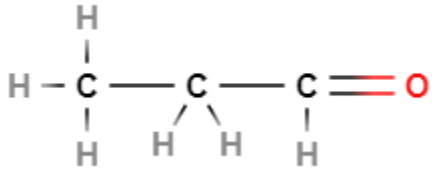
$$2.5 \times 10^{-6} = \frac{(2x)^2(x)}{1.0449^2}$$

0.000002729… = 4x^3
x = 0.00880400079… M
c(NO) = 2x
c(NO) = 2 × 0.00880400079…
c(NO) = 0.01760800... M rounded to 0.018 M (2 sig fig)

Question 28 (a)

Marking Criteria	Marks
Name AND draw the structural formula in reaction 2	2
Name OR draw the structural formula in reaction 2	1

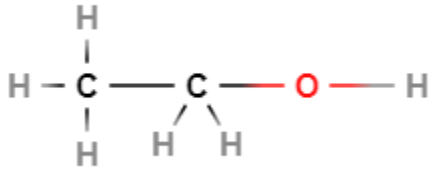
Sample Answer
Propanal



Question 28 (b)

Marking Criteria	Marks
Name AND draw the structural formula in reaction 5	2
Name OR draw the structural formula in reaction 5	1

Sample Answer
Ethanol



Question 28 (c)

Marking Criteria	Marks
Identify the type of reaction in reaction 6	1

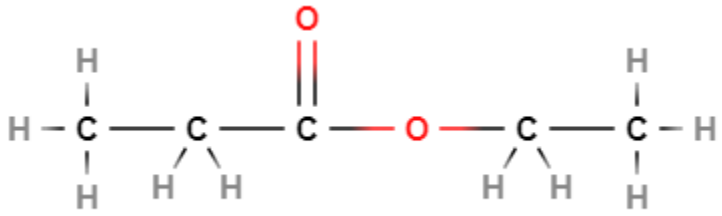
Sample Answer
Esterification

Question 28 (d)

Marking Criteria	Marks
Name AND draw the structural formula in reaction 6	2

Name OR draw the structural formula in reaction 6	1

Sample Answer
Ethyl propanoate



Question 29

Marking Criteria	Marks
Correctly calculate the volume of ethanol required to heat the setup	4
Correctly calculate the mass or moles of ethanol required to heat the setup	3
Correctly calculate the mass or moles of ethanol required to heat the setup without taking into the account the heat lost	2
Correctly calculate the total amount of energy needed to heat the water and the copper calorimeter	1

Sample Answer
$\Delta H = mc\Delta T$
$\Delta H = \Delta H$ to heat the water + ΔH to heat the copper pot
$\Delta H = 100 \times 4.18 \times 10 + 20 \times 0.385 \times 10$
$\Delta H = 4180 + 77$
$\Delta H = 4257J$
Since 70% of the energy is lost, 30% = 4257J, therefore 100% = 14190J
Molar Heat of Combustion = Energy / Moles of fuel burnt
1370000 = 14190 / Moles of Ethanol
Moles of Ethanol = 0.01035766… moles
The molar mass of ethanol = 46.068
Mass of ethanol = 0.4771568...
The volume of ethanol = mass of ethanol ÷ density of ethanol
The volume of ethanol = 0.4771568 ÷ 0.789
The volume of ethanol = 0.6047615…
The volume of ethanol = 0.605 mL rounded to 3 sig fig

Question 30 (a)

Marking Criteria	Marks
Correctly write a balanced chemical equation	1

Sample Answer

$H_2SO_{4(aq)} + 2NaOH_{(aq)} \rightarrow 2H_2O_{(l)} + Na_2SO_{4(aq)}$

Question 30 (b)

Marking Criteria	Marks
Calculate the pH of the neutralisation reaction	3
Correctly calculate the limiting agents and the excess NaOH but did not calculate the pH correctly	2
Correctly determined the limiting reagent	1

Sample Answer

Find the limiting reagent,

$n(H_2SO_4) = c(H_2SO_4) \times v(H_2SO_4)$

$n(H_2SO_4) = 0.5 \times 0.02$

$n(H_2SO_4) = 0.01$ moles

$n(NaOH) = c(NaOH) \times v(NaOH)$

$n(NaOH) = 0.8 \times 0.03$

$n(NaOH) = 0.024$ moles

Ratio of H_2SO_4 to NaOH is 1:2

Therefore 0.01 moles of H_2SO_4 will be used and 0.02 moles of NaOH will be used.

There will be 0.004 moles of NaOH leftover

Concentration of NaOH = 0.004 / 0.05

Concentration of NaOH = 0.08 M

Assuming that NaOH fully dissociate

$NaOH \rightarrow Na^+ + OH^-$

Concentration of OH^- = 0.08 M

pOH = -log(0.08)

pOH = 1.09691…

pH = 14 - pOH

pH = 12.9030… rounded to 12.9 (1dp)

Question 31 (a)

Marking Criteria	Marks
Correctly write a balanced chemical equation including states.	1

Sample Answer
$BaCl_{2(aq)} + Na_2SO_{4(aq)} \rightarrow BaSO_{4(s)} + 2NaCl_{(aq)}$

Question 31 (b)

Marking Criteria	Marks
Correctly calculated the moles of BaCl	2
Identify the precipitate is $BaSO_4$ and calculate the moles of $BaSO_4$	1

Sample Answer
Moles of $BaSO_4$ = 1.37 / 233.37
Moles of $BaSO_4$ = 0.0058705…
Ratio of $BaCl_2$ to $BaSo_4$ is 1:1
Therefore moles of $BaCl_2$ = 0.0058705…
Mass of $BaCl_2$ = 1.222239…
Mass of $BaCl_2$ = 1.22g (2 sig fig)

Question 31 (c)

Marking Criteria	Marks
Correctly calculation the %(w/w) of barium chloride	1

Sample Answer
%(w/w) of Barium chloride = (1.22 / 14.35) × 100
%(w/w) of Barium chloride = 8.5173…
%(w/w) of Barium chloride = 8.52% (3 sig fig)

Question 32 (a)

Marking Criteria	Marks
Correctly identify an appropriate indicator for the titration	1

Sample Answer

Strong acid + Strong base titration, therefore: Bromothymol blue

Question 32 (b)

Marking Criteria	Marks
Correct calculate the excess moles of NaOH	1

Sample Answer
$HCl_{(aq)} + NaOH_{(aq)} \rightarrow H_2O_{(l)} + NaCl_{(aq)}$
Moles of HCl used = 0.10 × 0.0189
Moles of HCl used = 0.00189 moles
Since the mole ratio of HCl to NaOH is 1:1
Moles of NaOH = 0.00189

Question 32 (c)

Marking Criteria	Marks
Correctly calculate the NaOH reacted with the aspirin	1

Sample Answer
Moles of NaOH reacted = Moles of NaOH in the initial solution - Moles of NaOH in excess
Moles of NaOH in the initial solution = 0.1 × 0.03
Moles of NaOH in the initial solution = 0.003 moles
Moles of NaOH reacted = 0.003 - 0.00189
Moles of NaOH reacted = 0.00111 moles

Question 32 (d)

Marking Criteria	Marks
Correctly calculate the mass of aspirin in the tablet	3
Correctly calculate the concentration of the concentrated aspirin solution	2
Correctly the concentration of the diluted aspirin solution	1

Sample Answer
The ratio of aspirin to NaOH is 1:2
Therefore the moles of Aspirin = 0.00111 ÷ 2
Moles of Aspirin = 0.000555

Conc of diluted aspirin solution = 0.000555 ÷ 0.025
Conc of diluted aspirin solution = 0.0222
To calculate the original concentration of the aspirin solution, use $c_1v_1 = c_2v_2$
$0.0222 \times 250 = c_2 \times 100$
Concentration of original aspirin solution = 0.0555 M
Moles of aspirin = 0.0555 × 0.25
Moles of aspirin = 0.013875
Mass of aspirin = 0.013875 × 180.154
Mass of aspirin = 2.499636…
Mass of aspirin = 2.50 g (3 sig fig)

Question 33

Marking Criteria	Marks
Correctly identify and explain the conditions and effects at T_1, T_2 and T_3	6
Correctly identify and explain most of the conditions and effects at T_1, T_2 and T_3	5
Correctly identify and explain some of the conditions and effects at T_1, T_2 and T_3	4
Correctly identify and explain some of the conditions at T_1, T_2 and T_3	3
Correctly identify and explain the conditions at ONE time interval	2
Correctly identify the conditions at T_1, T_2 and T_3	1

Sample Answer
At T_1 the equilibrium was affected by an increase in temperature, this causes the equilibrium to shift towards the reactant side as shown on the graph. This is because the forward reaction is exothermic and according to LCP, the equilibrium will shift to opposite the change which is to reduce the temperature. We can see that this is an increase in temperature as there are no sudden changes in concentration for any of the substances.
At T_2, the pressure of the system increases, this causes the equilibrium to shift to the product side as this is the side with the lower number of gas molecules. This is in accordance to LCP where the equilibrium will shift to reduce the pressure to counteract the change. We can see at T_2, the pressure is increased because all three substances suddenly have an instantaneous increase in concentration.
At T_3 the concentration of the Cl_2 decreases, this causes the equilibrium to shift towards the reactant side. According to LCP, the equilibrium will shift to oppose the change in this case to replace the lost Cl_2. We can see that the Cl_2 gas is lost as it is the only substance out of the three that has an instantaneous loss in concentration.

Question 34 (a)

Marking Criteria	Marks
Define saponification and outline the production of soap Write an appropriate balanced word equation for saponification	3
Define saponification and outline the production of soap	2
Define saponification	1

Sample Answer

Saponification is the reverse process of esterification, an ester will react with hydroxide to form an alcohol and an acid.

In the production of soaps, a triglyceride reacts with concentrated sodium hydroxide solution under reflux conditions, a glyceride and a soap is formed

Triglyceride + Sodium hydroxide ⇌ glycerol + salt of fatty acid

Question 34 (b)

Marking 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 molecules 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 droplet to form (micelle) ● The grease droplet is held in solution and attracted to the water molecules by anion on the droplet's surface ● Forms an emulsions and grease is washed away	3
Detailed explanation of the process linking the structure of the surfactant to its ability to form an emulsion in water with grease.	2
State that soap is a surfactant and can form an emulsion with grease and water	1

Sample answer

Grease is a non-polar substance and water is a polar substance normally they did not mix well and this explains why it is difficult to wash grease from dirty dishes and clothing.

A soap molecule is a surfactant and has a hydrophilic and hydrophobic end. The hydrophilic end is attracted to the water and the hydrophobic end is attracted to the grease. The surfactant forms a micelle around the grease molecule allowing the grease to dissolve in the water forming an emulsion. This emulsion can then be washed away by the currents of water cleaning the clothing or dish.

Question 35 (a)

Marking Criteria	Marks
Correctly define both strength and concentration of acids	1

Sample Answer

The strength of acids refers to the degrees of ionisation, a strong acids ionises completely whereas a weak acid only ionises partially.

The concentration of acids refers to how many molecules of acid in a fixed volume of solution. A concentrated acid contains many molecules of acid whereas a diluted acid contains very few molecules of acids.

Question 35 (b)

Marking Criteria	Marks
Correctly rank the strength of acids with a valid explanation.	2
Correct rank the strength of acid	1

Sample Answer

The strength of the acids is dependent on the pK_a, a lower pK_a value means that the acid dissociates more than higher values. Therefore, the ranking from the strongest to weakest are HCl, CH_3COOH and H_2CO_3

Question 35 (c)

Marking Criteria	Marks
Correctly rank the acid which requires the most NaOH to the least and provide a valid explanation	2
Correctly rank the acid which requires the most NaOH to the leas	1

Sample Answer

In neutralisation reactions such as in the titration, all of the bases will be consumed in the reaction due to LCP. It does not matter if the acid is weak or strong. Therefore the amount of NaOH needed in the reaction is based on the concentration and the how many protons the acid can donate.

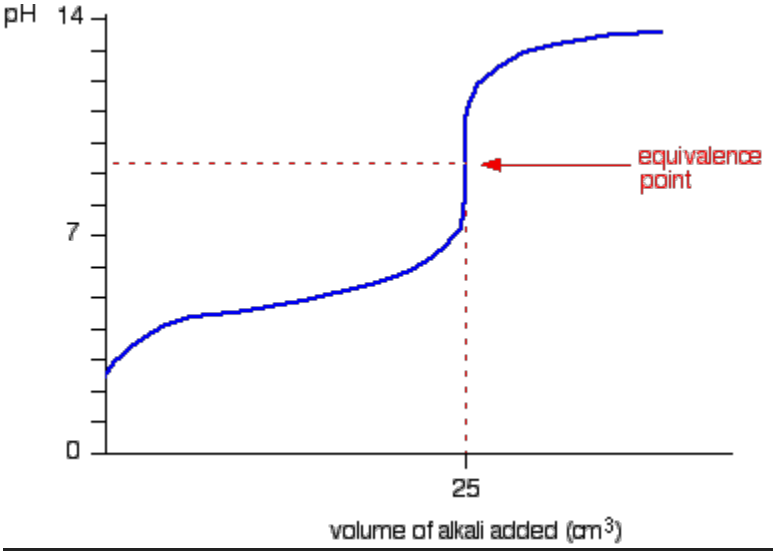
H_2CO_3 will require the most amount of NaOH, since all three acids have the same concentration but H_2CO_3 is diprotic and requires twice as much base to neutralise.

Since HCl and CH_3COOH have the same concentration, they will need equal amounts of NaOH to reach the equivalence point.

Question 35 (d)

Marking Criteria	Marks
The graph correctly shows the equivalence point above pH 7 and that the graph shows base running into acid	2
The graph shows ONE of the above.	1

Sample Answer



Question 36 (a)

Marking Criteria	Marks
Correctly calculate the enthalpy and entropy of reaction Correctly calculate the gibbs free energy and use the correct unit for gibbs free energy.	3
Correctly calculate the enthalpy and entropy of reaction Correctly calculate the gibbs free energy	2
Correctly calculate the enthalpy and entropy of reaction	1

Sample Answer

ΔH = Enthalpy of formation of product - enthalpy of formation of reactants

$\Delta H = (-157) + (-242) - (-450)$

$\Delta H = 51\ kJmol^{-1}$

$\Delta S = 43 + 189 - 108$

$\Delta S = 124\ JK^{-1}mol^{-1} = 0.124\ kJK^{-1}mol^{-1}$

$\Delta G = \Delta H - T\Delta S$
$\Delta G = 51 - 500(0.124)$
$\Delta G = -11\ kJmol^{-1}$

Question 36 (b)

Marking Criteria	Marks
Conclude that the reaction is spontaneous	1

Sample Answer
The reaction is spontaneous because the gibbs free energy is negative.

Question 36 (c)

Marking Criteria	Marks
Correctly calculate the temperature at which the reaction becomes an equilibrium.	1

Sample Answer
Reaction is an equilibrium when $\Delta G = 0$
$\Delta G = \Delta H - T\Delta S$
$0 = 51 - T(0.124)$
$T(0.124) = 51$
$T = 411$
$T = 411K$ (2 sig fig)