CSSA

2022
TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

MARKING GUIDELINES

Chemistry

Section I
20 marks

Questions 1-20 (1 mark each)

Question	Answer	Outcomes Assessed	Targeted Performance Band
1	D	CH12-5, CH-12-14	2-3
2	A	CH12-5	2-3
3	D	CH12-6, CH12-14	2-3
4	B	CH12-5, CH12-6, CH12-12	3-4
5	A	CH12-6, CH12-12	3-4
6	C	CH12-5, CH12-13	3-4
7	C	CH12-6, CH12-7, CH12-14	3-4
8	B	CH12-6, CH12-14	3-4
9	C	CH12-3, CH12-14	2-3
10	A	CH12-4, CH12-14	4-5
11	C	CH12-5	3-4
12	C	CH12-6	3-4
13	B	CH12-6, CH12-15	3-4
14	B	CH12-5, CH12-6, CH12-14	4-5
15	B	CH12-6, CH12-12	4-5
16	A	CH12-5, CH12-6, CH12-15	4-5
17	A	CH12-5, CH12-6, CH12-12	5-6
18	B	CH12-5, CH12-6, CH12-13	4-5
19	D	CH12-6, CH12-13	4-5
20	D	CH12-4, CH12-15	5-6

Section II
80 marks

Question 21 (4 marks)
Outcomes Assessed: CH12-5, CH12-6
Targeted Performance Bands: 3-5

Criteria	Marks
• Uses correct chemical equation to calculate ionic product AND • Compares IP to K_{sp} from data table to determine if ppt forms	4
• Uses correct chemical equation to incorrectly calculate ionic product AND • Compares IP to K_{sp} from data table to determine if ppt forms	3
• Uses incorrect chemical equation to calculate IP AND • Compares IP to K_{sp} from data table to determine if ppt forms	2
• Calculates incorrect IP and states if ppt forms (no reference to data table) OR • Some relevant information	1

Sample Answer:

$PbCl_2\ (s) \rightleftharpoons Pb^{2+}(aq) + 2\ Cl^-\ (aq) \quad Ksp = 1.2 \times 10^{-5}$

mol Pb^{2+} (aq) = (0.150 L)(0.10 mol Pb^{2+}/L) = 0.015 mol

$[Pb^{2+}] = 0.015$ mol/0.250 L = 0.060 M

mol Cl^- (aq) = 0.100 L) (0.20 mol Cl^-/L) = 0.020 mol

$[Cl^-] = 0.020$ mol/0.250 L = 0.080 M

Ionic Product, $Q = [Pb^{2+}][Cl^-]^2 = (0.060)(0.080)^2 = 3.8 \times 10^{-4}$

$Q > K_{sp}$, so $PbCl_2$ will precipitate from solution.

Question 22 (5 marks)
(a) (2 marks)
Outcomes Assessed: CH12-14
Targeted Performance Bands: 2-4

Criteria	Marks
• Provides two advantages for using ethanol as a biofuel	2
• Provides one advantage	1

Sample Answer:

Biofuels, such as ethanol are produced from renewable resources and therefore not be depleted, like fossil fuels. Biofuels are essentially carbon neutral, as the carbon dioxide produced in their combustion is re-used in photosynthesis.

(b) 3 marks
Outcomes Assessed: CH12-14
Targeted Performance Bands: 3-5

Criteria	Marks
• Correctly calculates the energy released	3
• Provides substantially correct working out towards calculating the energy released	2
• Provides some relevant understanding	1

Sample Answer:

Density = mass/volume
Mass (ethanol) = density x volume
= 0.78 g/mL x 60 L x 1000 mL/L
= 46800g

Moles (ethanol) = mass/molar mass
= 46800 / 46
= 1071.3913 mol

Energy released = moles x heat of combustion
= 1017.3913 mol x 1370 kJ/mol
= 1393826.09 kJ
= 1400 MJ

Question 23 (5 marks)

(a) 1 mark

Outcomes Assessed: CH12-14

Targeted Performance Bands: 2-3

Criteria	Marks
• Correctly identifies the compound	1

Sample Answer:

1-butanol or butan-1-ol.

(b) 2 marks

Outcomes Assessed: CH12-14

Targeted Performance Bands: 2-3

Criteria	Marks
• Correctly defines the term homologous series • Correctly uses one or more of the compounds as an example	2
• Provides some relevant information	1

Sample Answer:

A homologous series is a set of compounds with the same functional group, just with differing numbers of carbons. Compound Y is part of the primary alcohol homologous series with general formula $C_nH_{2n+1}OH$.

(c) 2 marks

Outcomes Assessed: CH12-14

Targeted Performance Bands: 2-3

Criteria	Marks
• Correctly defines the term position isomer • Correctly uses one or more of the compounds as an example	2
• Provides some relevant information	1

Sample Answer:

Position isomers have the same chemical formula and the same functional group, but the functional group is located on a different part of the carbon skeleton. Compound X and Compound Y both have 4 carbons in a linear chain and a hydroxyl group, but the hydroxyl group is in a different position on the chain.

(d) 4 marks

Outcomes Assessed: CH12-14

Targeted Performance Bands: 3-4

Criteria	Marks
• Correctly identifies the products formed from the oxidation of Compounds X and Y AND • Correctly identifies no reaction with Compound Z	3-4
• Correctly identifies ONE product from the oxidation of Compounds X and Y OR • Correctly identifies that both Compounds X and Y will react, but Compound Z will not react	2
• Provides some relevant information	1

Sample Answer:

Compound X is a secondary alcohol, so will oxidise with acidified potassium permanganate to form a ketone, butanone. Compound Y is a primary alcohol, so will oxidise with acidified potassium permanganate (a strong oxidising agent) to form a carboxylic acid, butanoic acid. Compound Z is a tertiary alcohol, so will not react with acidified potassium permanganate.

Question 24 (4 marks)
Outcomes Assessed: CH12-2, CH12-13
Targeted Performance Bands: 4-5

Criteria	Marks
• Describes a suitable method, including required mass of dried solid, dissolution in minimum distilled water, transfer to volumetric flask which is filled to the mark and agitated to ensure mixing. • Verification using known concentration of HCl and a suitable indicator to titrate known volume of boric acid and appropriate calculation with 1:4 mol ratio	5-6
• As above, but missing two major steps	3-4
• Describes a method and states how HCl can be used in a titration	2
• Provides some relevant information	1

Sample Answer:

Preparation
The required mass (or similar, known mass) of sodium borate octahydrate (0.150 mol L^{-1} x 0.250 L x 301.2 g moL^{-1} = 11.30 g) is dissolved in a small volume of distilled/deionised water. This is carefully transferred, using a funnel, into a clean 250.0 mL volumetric flask. Distilled water is added up to the graduation mark and the solution is inverted to ensure complete mixing occurs.

Verification
Sodium borate is a base containing 4 OH groups, therefore a strong acid, such as hydrochloric acid can be used to verify the concentration of the solution using titration.
For example, a 0.150 M solution contains 0.150 x 0.020 = 3.00 x 10^{-4} moles per 20.00 mL. That 20.00 mL sample will require 4 times as many mol of HCl. If this many mol are used, then the solution is 0.150 mol L^{-1} sodium borate octahydrate.

Question 25 (4 marks)
Outcomes Assessed: CH12-2, CH12-5
Targeted Performance Bands: 4-5

Criteria	Marks
• Evaluates the claim correctly by calculating the actual amount of calcium in two tablets and comparing it to the claim.	4
• Evaluates the claim based on a calculation that has one error OR • Evaluates the claim based on an incorrect equation and no calculation error	3
• Determines mass of calcium for one tablet	2
• Determines the mass of calcium using incorrect equation OR • Writes correct equation for precipitation	1

Sample Answer:

$3Ca^{2+}(aq) + 2PO_4^{-3}(aq) \rightarrow Ca_3(PO_4)_2(s)$

Mol of phosphate added. $= 0.0370 \times 0.16$

$= 0.00592$ mol

Mol of calcium ions = 3/2 x mol of phosphate = 0.00888 mol

Mass of Ca = 40.08×0.00888

$= 0.3559$ g

Mass in mg per tablet = 356 mg

Mass of 2 tablets = $356 \times 2 = 712$ mg

The company's statement is incorrect, as the amount of Calcium per tablet is 356 mg. Two tablets contain 712 mg which is below the quoted amount: 50% of 1450 = 725 mg, so the claims of the manufacture are false.

Question 26 (6 marks)

(a) 3 marks

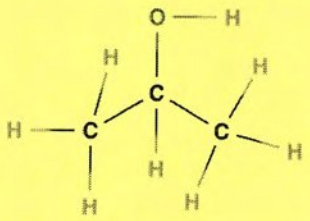
Outcomes Assessed: CH12-14

Targeted Performance Bands: 2-4

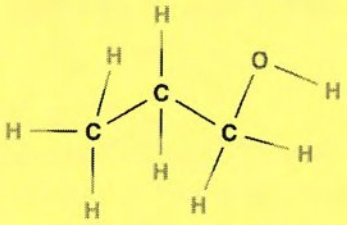
Criteria	Marks
• Provides correct structural formulae and names for compound A, B and C	3
• TWO of the above	2
• ONE of the above	1

Sample Answer:

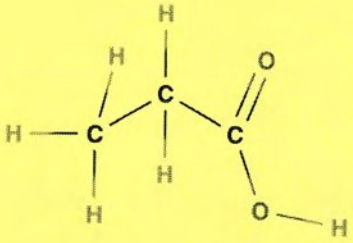
Compound A - Propan-2-ol



Compound B - Propan-1-ol



Compound C - Propanoic Acid



(b) 2 marks

Outcomes Assessed: CH12-14

Targeted Performance Bands: 2-4

Criteria	Marks
• Provides a correctly balanced symbol equation and names the products	2
• Writes correct equation (states not required) OR • Names the products	1

Sample Answer:

$C_4H_8O_2 + C_3H_8O \rightleftharpoons C_7H_{14}O_2 + H_2O$ (condensed structural formula accepted)

Products – Propyl butanoate and water

Question 27 (8 marks)
Outcomes Assessed: CH12-14, CH12-15
Targeted Performance Bands: 2-4
(a) 2 marks

Criteria	Marks
• Correctly determines the empirical formula	2
• Provides some relevant information	1

Sample Answer:

In 100 g, there are

66.0 g of carbon	6.5 g of hydrogen	12.8 g of nitrogen	14.7 g of oxygen
= 66.0/12.0 mol of C	= 6.5/1.008 mol of H	= 12.8/14.01 mol of N	= 14.7/16.01 mol of O
= 5.5 mol of C	= 6.45 mol of H	= 0.914 mol of N	= 0.918 mol of O

Therefore,
n(C): n(H): n(N): n(O) = 5.5:6.45:0.914:0.918 (divide by 0.914)
= 6.0:7.1:1:1.0
= 6:7:1:1 (whole numbers)
The empirical formula is C_6H_7NO

Outcomes Assessed: CH12-14, CH12-15
Targeted Performance Bands: 2-4
(b) 1 mark

Criteria	Mark
• Correctly determines the molecular mass of Compound B	1

Sample Answer:

Based on the mass spectrum, the molecular mass is 60 g/mol.

Outcomes Assessed: CH12-14, Ch12-15
Targeted Performance Bands: 2-5
(c) 3 marks

Criteria	Marks
• Correctly identifies and explains ONE important feature for each compound	3
• Correctly identifies ONE important feature for each compound OR • Correctly identifies and explains ONE feature for each compound	2
• Provides some relevant information	1

Sample Answer:

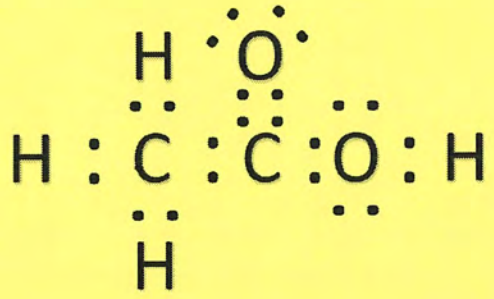
For Compound A, there is a sharp peak at 3350 cm^{-1}, indicating a N-H amine bond. (1630 cm^{-1} would indicate a C=C bond, but this would not really help unlock the structure of Compound A, given the structure of paracetamol. There are two peaks around 3300 cm^{-1} and 3350 cm^{-1}. Normally the -OH alcohol bond is broad, so these sharper peaks are not good for identifying the-OH structure). For Compound B, there is a very broad band centred on 3000 cm^{-1}, indicative of an acidic -OH group. (There is also a peak at 1700 cm^{-1}, but given the C=O in the structure of paracetamol, this does not help a great deal in determining the structure of Compound B).

Outcomes Assessed: CH!2-14, CH12-15
Targeted Performance Bands: 2-3

(d) 2 marks

Criteria	Marks
• Correctly draws the electron dot diagram	2
• Provides most elements of the electron dot diagram	1

Sample Answer:



Question 28 (4 marks)
Outcomes Assessed: CH12-15
Targeted Performance Bands: 4-6

Criteria	Marks
• Discusses the impact of the production process on the environment AND • Discusses the need for the production process AND • Provides a judgement on the impact of the production process on the environment	4
• Provides ONE impact and AND ONE reason on the importance of the chemical OR • Provides ONE impact/reason on the importance of the chemical AND provides a judgement	3
• Provides ONE impact on the environment OR • Provides ONE reason on the importance of the chemical	2
• Any relevant information	1

Sample Answer:

Ammonia is produced by reacting nitrogen and hydrogen in a synthesis called the Haber process. Ammonia has many applications and is widely relied upon by society to make fertilisers, plastics, cleaning products etc. The production of it can result in negative impacts on the environment. For example, the power required to generate the correct temperatures and high pressures to produce ammonia uses mostly fossil fuels, generating greenhouse gases. The sourcing of reactants produces greenhouse gases which further contributes to global warming. A great advantage of the process is that there is only one product from the synthesis, so the atom economy is high, and no waste chemical is formed. Although the production of ammonia has a negative impact on the environment, the utilisation of ammonia in industry has had an overwhelming positive impact on society.

Question 29 (5 marks)
Outcomes Assessed: CH12-7, CH12-12
Targeted Performance Bands: 3-5

Criteria	Marks
• Details features of equilibrium v non-equilibrium systems using correct terminology AND • Relates spontaneity to reaction enthalpy and entropy to each process AND/OR • Calculates **ΔG** using provided data and relates positive value to a non-spontaneous process for photosynthesis	4-5
• Provides some features of equilibrium and non-equilibrium systems AND • Identifies the enthalpy or entropy change for photosynthesis	3
• Provides some features of equilibrium and non-equilibrium systems OR • Identifies the enthalpy or entropy change for photosynthesis	2
• Provides relevant information	1

Sample Answer:

Although the photosynthesis reaction can be seen via the equation to be the reverse of respiration the two reactions are not part of an equilibrium system and are distinctly different processes.
A dynamic equilibrium is one that is spontaneous and reversible, a non-equilibrium system is one in which the reactions only occur in one direction to make the products and does not spontaneously shift back to the reactants. As photosynthesis takes place in plant cells where chemicals are moved within the cell depending on the reaction required, it is an open system (not a closed system which is required for a dynamic equilibrium).
The process of photosynthesis is endothermic ($\Delta H_{reaction} > 0$) with the required energy being supplied by the absorption of energy from the sun. The glucose molecule, being a more complex molecule than the starting components means that order within the system has been increased which means a decrease in entropy occurs within the system ($\Delta S_{reaction} < 0$). As energy is required for the process and as entropy is decreased this then results in the Gibbs free energy, $\mathbf{\Delta G = \Delta H - T \Delta S}$ being positive.
For a reaction to be spontaneous, Gibbs free energy has to be less than zero.
Therefore, due to these factors photosynthesis is not an equilibrium reaction and is not the reverse of aerobic respiration.

Question 30 (6 marks)
Outcomes Assessed: CH12-5
Targeted Performance Bands: 3-5
(a) 3 marks

Criteria	Marks
• Explains the shape of a curve due to buffering – enough base is available to use up added H^+ until 20 mL of acid is added AND • This curve demonstrates high buffering capacity AND • Buffering capacity is reduced after 20 mL as the acid added is now in excess, resulting in rapid pH decrease	3
• Identifies that there is a buffer. • State buffer ion (base component has been used up)	2
• Identifies that the solution is a buffer/buffering is occurring.	1

Sample Answer:

As acid is added to the solution there is a resistance to the change in pH, so it is acting as a buffer. Buffers contain significant concentrations of the base and its conjugate acid (or a weak acid and its conjugate base). As the acid continues to be added the base component of the buffer (hydrogen acceptor) is being used up and runs out when the curve descends after 20 mL. At this point the solution can longer resist the change in pH, so the solution pH rapidly drops as the concentration of H^+ increases.

Outcomes Assessed: CH12-5, CH12-13
Targeted Performance Bands: 3-5
(b) 3 marks

Criteria	Marks
• States valid equilibrium equation for a natural system • Explains what happens if acid is added and if base is added. • Clear statement about the shift in the equilibrium	3
• States valid equilibrium equation • States what happens if acid is added and if base is added	2
• Names a buffer system	1

Sample Answer:

Blood contains several buffers, one of which is the carbonic acid, H_2CO_3 (aq)/hydrogen carbonate ion, HCO_3^- (aq) equlibrium. This buffer contains both the base and the conjugate acid in significant concentrations, enabling the equilibrium to shift left or right as required, to maintain blood pH at approximately 7.4.

Reaction 1: Acting as a base when extra acid is added

$$HCO_3^-(aq) + H_3O^+(aq) \rightleftharpoons H_2O(l) + H_2CO_3(aq)$$

Reaction 2: Acting as an acid when base is added

$$OH^-(aq) + H_2CO_3(aq) \rightleftharpoons HCO_3^-(aq) + H_2O(aq)$$

When a small amount of acid is added the hydrogen carbonate reacts to minimise the change in pH. Reaction 1 will occur.

If a base is added the carbonic acid will react to minimise the change in pH. Reaction 2 will occur.

Question 31 (7 marks)
Outcomes Assessed: CH12-15
Targeted Performance Bands: 2-6

Criteria	Marks
• Outlines valid methods, with approximate quantities, for BOTH copper and chloride • Provides valid observations, including colour, for confirmation • Includes a flame test, precipitation reaction AND a complexation reaction	6-7
• Meets MOST of the above criteria	4-5
• Meets SOME of the above criteria	2-3
• Provides some relevant information	1

Sample Answer:

Method – testing for copper

1) Place a pea-sized sample of the powder on a watch glass.
2) Wet a metal loop with some distilled water and coat it with the powder.
3) Place the coated metal loop into the tip of the blue Bunsen flame. If it is copper, the flame should turn blue-green.
4) Place a pea-sized sample of the powder into a test tube a fill the test tube with distilled water, to a depth of 5 cm. Stir to dissolve.
5) Add a few drops of 3.0 M ammonia solution and a pale blue copper hydroxide precipitation should form.
6) Add more ammonia solution until the precipitate dissolves and the copper returns to solution as a deep blue ammonia complex.

Method – testing for chloride

7) Place a pea-sized sample of the powder into a test tube a fill the test tube with distilled water, to a depth of 3 cm. Stir to dissolve.
8) Add a few drops of 0.1 M silver nitrate. A greyish-brown silver chloride precipitate should form.

Question 32 (4 marks)
Outcomes Assessed: CH12-14
Targeted Performance Bands: 3-5

Criteria	Marks
• Correctly accounts for the trend in both homologous series AND • Correctly identifies the different in bonding between the two homologous series AND • Correctly links strength of bond to the boiling point	4
• Correctly accounts for the trend in both homologous series AND • Correctly identifies the different in bonding between the two homologous series OR • Correctly accounts for the trend in both homologous series AND • Correctly links strength of bond to the boiling point	3
• Correctly accounts for the trend in both homologous series	2
• Any relevant information	1

Sample Answer:

Both homologous series show an increase in boiling point as chain length increases. This is due to an increase in the number of dispersion forces between molecules. More energy is required to break the increasing number of forces. Alkanes only contain weak dispersion forces between molecules whereas alcohols can also form stronger hydrogen bonds between molecules. Hydrogen bonds require more energy to break than dispersion forces hence alcohols with the same number of carbons have higher boiling point than their respective alkane. As the chain length increases the increasing amount of dispersion forces becomes more significant, resulting in the boiling points for the series becoming closer.

Question 33 (6 marks)

(a) 1 mark

Outcomes Assessed: CH12-2

Targeted Performance Bands: 2-4

Criteria	Marks
• Completes volume used and identifies appropriate indicator	2
• Completes volume used or identifies appropriate indicator	1

Sample Answer:

Volume used (mL)	Trial 1	Trial 2	Trial 3
	25.79	25.31	25.25
Indicator	Phenolphthalein		

(b) (4 marks)

Outcomes Assessed: CH12-2, CH12-5, CH12-13

Targeted Performance Bands:2-6

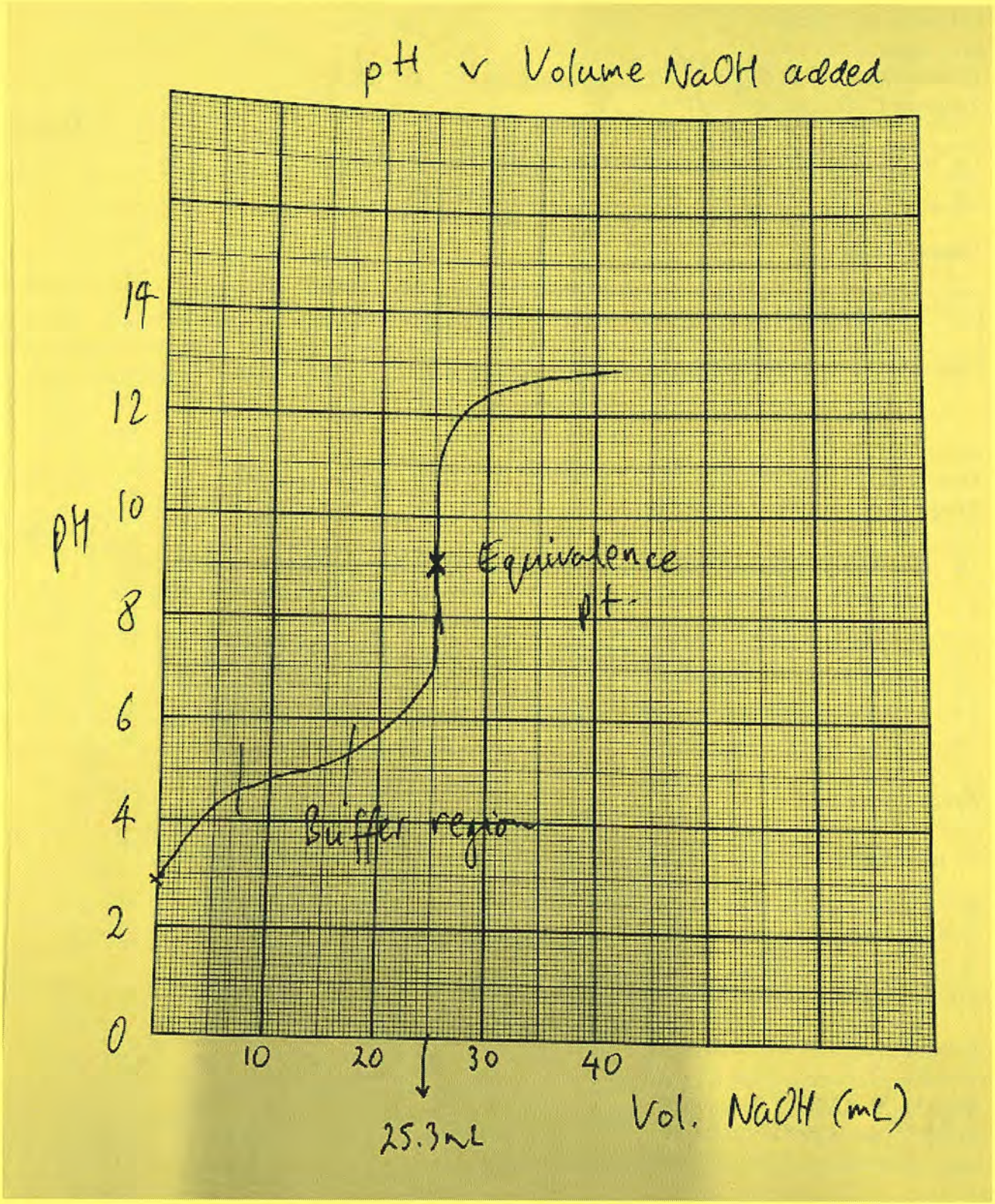
Criteria	Marks
• Constructs a typical, labelled curve for weak acid/strong base starting at correct pH calculated from K_a and showing volume of NaOH at equivalence point matching the average vol from (a)	4
• As above but has incorrect starting pH based on calculation from K_a OR has incorrect volume at equivalence point	3
• Draws a typical curve for weak acid/strong base	2
• Draws a titration curve	1

Sample Answer:

Average titration volume is 25.28 mL. This is the volume at the equivalence point.

$K = 1.7 \times 10^{-5} = XxX/0.1-X$
$X^2 = 0.1 \times 1.7 \times 10^{-5}$
$X = [H^+] = 0.0013$ mol L^{-1}
pH = 2.89 This will be the initial pH

x-axis has volume of NaOH (mL)
y-axis is pH from 0-14 or similar
starting pH is 2.9 (or close to it)
buffer region is part of the curve
equivalence point is around 9-10 at correct volume.



Question 34 (6 marks)
Outcomes Assessed: CH12-4, CH12-6, CH12-12
Targeted Performance Bands: 3-6

Criteria	Marks
• Correctly calculates the three solubilities, ranking them AND • Accounts in detail for differences in solubility for each salt in terms of common ion effect and Le Chatelier's Principle	5-6
• Correctly calculates two of the solubilities AND • Accounts in detail for differences in solubility for each salt in terms of common ion effect and Le Chatelier's Principle OR • Correctly calculates three solubilities AND • Accounts for differences in general terms (not specific to each salt)	3-4
• Calculates one or two solubilities correctly and states the cause is the common ion effect OR • Uses Le Chatelier's Principle to describe why the solubility will change	2
• Some relevant information	1

Sample Answer:

K_{sp} (PbI_2) = 9.8×10^{-9}

PbI_2 (s) ⇌ Pb^{2+} (aq) + $2I^-$ (aq)
Let solubility = s
Then $9.8 \times 10^{-9} = (s)(2s)^2$
And s = 0.000135 mol L^{-1}

In 0.1 M $Pb(NO_3)_2$, $[Pb^{2+}] = 0.1 + s$ Assume $s << 0.1$
Then $9.8 \times 10^{-9} = (0.1)(2s)^2$
And s = 0.000156 mol L^{-1} Note: the assumption is valid

In 0.1 M MgI_2 $[Pb^{2+}]$ = s and $[I^-] = 0.2 + 2s$ Assume $2s << 0.2$
Then $9.8 \times 10^{-9} = (s)(0.2+ 2s)^2$
And $s = 2.5 \times 10^{-7}$ mol L^{-1}

The solubility is greatest in water and least in MgI_2. When the lead iodide is added to the two salt solutions the solubility decreases due to the common ion effect. In lead nitrate the common ion is Pb^{2+}, so the equilibrium is shifted to the left, as predicted by Le Chatelier's Principle, to minimise the change: PbI_2 (s) ⇌ Pb^{2+} (aq) + $2I^-$ (aq)

In magnesium iodide the common ion is I^- so the equilibrium shifts to the left as well. However, the increase in concentration of iodide ions was two times greater than that for lead ions, so the shift was more pronounced in magnesium iodide solution.

Question 35 (3 marks)
Outcomes Assessed: CH12-7, CH12-12
Targeted Performance Bands: 3-6

Criteria	Marks
• Describes the effect on K AND • degree of ionisation using equilibrium theory AND • includes a suitable equation	3
• Describes the effect on K OR degree of ionisation AND • includes a suitable equation	2
• One of the above	1

Sample Answer:

K_a is given at a specific temperature and only changes if the temperature changes. In this case there is no temperature change, so K remains constant.
$CH_3CH_2COOH\ (aq) + H_2O\ (l) \rightleftharpoons CH_3CH_2COO^-\ (aq) + H_3O^+\ (aq)$
Evaporation removes water, so the system will shift left to replace the water. Consequently, there will be less $CH_3CH_2COO^-\ (aq)$ and $H_3O^+\ (aq)$ and more $CH_3CH_2COOH\ (aq)$ and the degree of ionisation will be reduced.