

Amount of substance

Question Paper

Level	A Level
Subject	Chemistry
Exam Board	AQA
Topic	Physical Chemistry
Sub Topic	Amount of substance
Booklet	Question Paper
Paper type	Multiple choice

Time Allowed: 54 minutes

Score: /54

Percentage: /100

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

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Q1. Which of these pieces of apparatus has the lowest percentage uncertainty in the measurement shown?

- A** Volume of 25 cm³ measured with a burette with an uncertainty of ± 0.1 cm³.
- B** Volume of 25 cm³ measured with a measuring cylinder with an uncertainty of ± 0.5 cm³.
- C** Mass of 0.150 g measured with a balance with an uncertainty of ± 0.001 g.
- D** Temperature change of 23.2 °C measured with a thermometer with an uncertainty of ± 0.1 °C.

(Total 1 mark)

Q2. A student is provided with a 5.00 cm³ sample of 1.00×10^{-2} mol dm⁻³ hydrochloric acid. The student is asked to devise a method to prepare a hydrochloric acid solution with a concentration of 5.00×10^{-4} mol dm⁻³ by diluting the sample with water.

Which of these is the correct volume of water that should be added?

- A** 45.0 cm³
- B** 95.0 cm³
- C** 100 cm³
- D** 995 cm³

(Total 1 mark)

Q3. Which of the following contains the most chloride ions?

- A** 10 cm³ of 3.30×10^{-2} mol dm⁻³ aluminium chloride solution
- B** 20 cm³ of 5.00×10^{-2} mol dm⁻³ calcium chloride solution
- C** 30 cm³ of 3.30×10^{-2} mol dm⁻³ hydrochloric acid
- D** 40 cm³ of 2.50×10^{-2} mol dm⁻³ sodium chloride solution

(Total 1 mark)

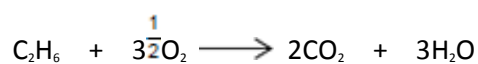
Q4. Which of these samples of gas contains the largest number of molecules?

The gas constant $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$.

- A** $5.0 \times 10^{-4} \text{ m}^3$ at $1.0 \times 10^6 \text{ Pa}$ and 300 K
- B** $4.0 \times 10^{-3} \text{ m}^3$ at $2.0 \times 10^5 \text{ Pa}$ and 400 K
- C** $3.0 \times 10^1 \text{ dm}^3$ at $3.0 \times 10^4 \text{ Pa}$ and 500 K
- D** $2.0 \times 10^2 \text{ dm}^3$ at $4.0 \times 10^3 \text{ Pa}$ and 600 K

(Total 1 mark)

Q5. What is the total volume of gas remaining after 20 cm³ ethane are burned completely in 100 cm³ oxygen? All volumes are measured at the same pressure and the same temperature, which is above 100 °C.



- A 40 cm³
- B 100 cm³
- C 120 cm³
- D 130 cm³

(Total 1 mark)

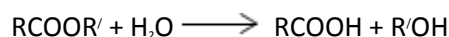
Q6. A sample of 2.18 g of oxygen gas has a volume of 1870 cm³ at a pressure of 101 kPa.

What is the temperature of the gas?
The gas constant is $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$.

- A 167 K
- B 334 K
- C 668 K
- D 334 000 K

(Total 1 mark)

Q7. An ester is hydrolysed as shown by the following equation.



What is the percentage yield of RCOOH when 0.50 g of RCOOH ($M_r = 100$) is obtained from 1.0 g of RCOOR' ($M_r = 150$)?

- A** 33%
- B** 50%
- C** 67%
- D** 75%

(Total 1 mark)

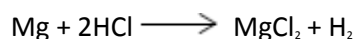
Q8. A saturated aqueous solution of magnesium hydroxide contains 1.17×10^{-3} g of $\text{Mg}(\text{OH})_2$ in 100 cm^3 of solution. In this solution, the magnesium hydroxide is fully dissociated into ions.

What is the concentration of $\text{Mg}^{2+}(\text{aq})$ ions in this solution?

- A** $2.82 \times 10^{-2} \text{ mol dm}^{-3}$
- B** $2.01 \times 10^{-3} \text{ mol dm}^{-3}$
- C** $2.82 \times 10^{-3} \text{ mol dm}^{-3}$
- D** $2.01 \times 10^{-4} \text{ mol dm}^{-3}$

(Total 1 mark)

Q9. Magnesium reacts with hydrochloric acid according to the following equation.



A student calculated the minimum volume of 2.56 mol dm^{-3} hydrochloric acid required to react with an excess of magnesium to form 5.46 g of magnesium chloride ($M_r = 95.3$).

Which of the following uses the correct standard form and the appropriate number of significant figures to give the correct result of the calculation?

- A** $4.476 \times 10^{-2} \text{ dm}^3$
- B** $4.48 \times 10^{-2} \text{ dm}^3$
- C** $4.50 \times 10^{-2} \text{ dm}^3$
- D** $44.8 \times 10^{-3} \text{ dm}^3$

(Total 1 mark)

Q10. In an experiment to identify a Group 2 metal (X), 0.102 g of X reacts with an excess of aqueous hydrochloric acid according to the following equation.



The volume of hydrogen gas given off is 65 cm^3 at 99 kPa pressure and 303 K .
The gas constant is $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$.

Which is X?

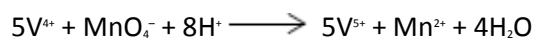
- A** Barium
- B** Calcium
- C** Magnesium
- D** Strontium

(Total 1 mark)

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Q11. The following equation represents the oxidation of vanadium(IV) ions by manganate(VII) ions in acid solution.

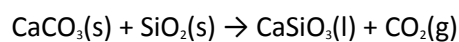


What volume of $0.020 \text{ mol dm}^{-3}$ $KMnO_4$ solution is required to oxidise completely a solution containing 0.010 mol of vanadium(IV) ions?

- A 10 cm^3
- B 25 cm^3
- C 50 cm^3
- D 100 cm^3

(Total 1 mark)

Q12. The removal of silicon dioxide with limestone in the Blast Furnace can be represented by the following equation.

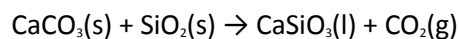


The minimum mass of calcium carbonate needed to remove 1.00 tonne (1000 kg) of silicon dioxide is

- A 0.46 tonne
- B 0.60 tonne
- C 1.67 tonne
- D 2.18 tonne

(Total 1 mark)

Q13. The removal of silicon dioxide with limestone in the Blast Furnace can be represented by the following equation.

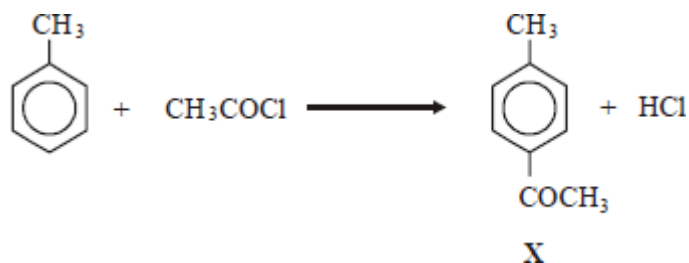


The volume of carbon dioxide, measured at 298 K and 1.01×10^5 Pa, formed in this reaction during the removal of 1.00 tonne (1000 kg) of silicon dioxide is

- A 24.5 dm³
- B 408 dm³
- C 24.5 m³
- D 408 m³

(Total 1 mark)

Q14. Ethanoyl chloride reacts with methylbenzene forming compound **X** according to the equation below.



If the experimental yield is 40.0%, the mass in grams of **X** ($M_r = 134.0$) formed from 18.4 g of methylbenzene ($M_r = 92.0$) is

- A 26.8
- B 16.1
- C 10.7
- D 7.4

(Total 1 mark)

Q15. When 0.10 g of propane was burned the quantity of heat evolved was 5.0 kJ. The enthalpy of combustion of propane in kJ mol^{-1} is

- A -800
- B -1500
- C -2200
- D -2900

(Total 1 mark)

Q16. 25.0 cm^3 of ethanedioic acid required 22.5 cm^3 of 0.100 mol dm^{-3} potassium hydroxide solution for complete neutralisation.

The concentration of ethanedioic acid is

- A 0.0225 mol dm^{-3}
- B 0.0450 mol dm^{-3}
- C 0.0560 mol dm^{-3}
- D 0.0900 mol dm^{-3}

(Total 1 mark)

Q17. Silver oxide, Ag_2O , can be reduced by passing hydrogen gas over the heated oxide. The maximum mass of silver that could be obtained from 2.32 g of silver oxide is

- A 2.02 g
- B 2.06 g
- C 2.12 g
- D 2.16 g

(Total 1 mark)

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Q18. In a reaction which gave a 27.0% yield, 5.00 g of methylbenzene were converted into the explosive 2,4,6-trinitromethylbenzene (TNT) ($M_r = 227.0$). The mass of TNT formed was

- A 1.35 g
- B 3.33 g
- C 3.65 g
- D 12.34 g

(Total 1 mark)

Q19. A 0.0720 g sample of reducing agent **R** was dissolved in water and acidified with an excess of dilute H_2SO_4 . The resulting solution was found to react with exactly 18.0 cm^3 of a $0.0200 \text{ mol dm}^{-3}$ solution of KMnO_4 .

In this reaction, 5 mol of **R** react with 3 mol of KMnO_4 . The M_r of **R** is

- A 120
- B 167
- C 240
- D 333

(Total 1 mark)

Q20. The percentage by mass of carbon is 83.3% in

- A propane.
- B butane.
- C pentane.
- D hexane.

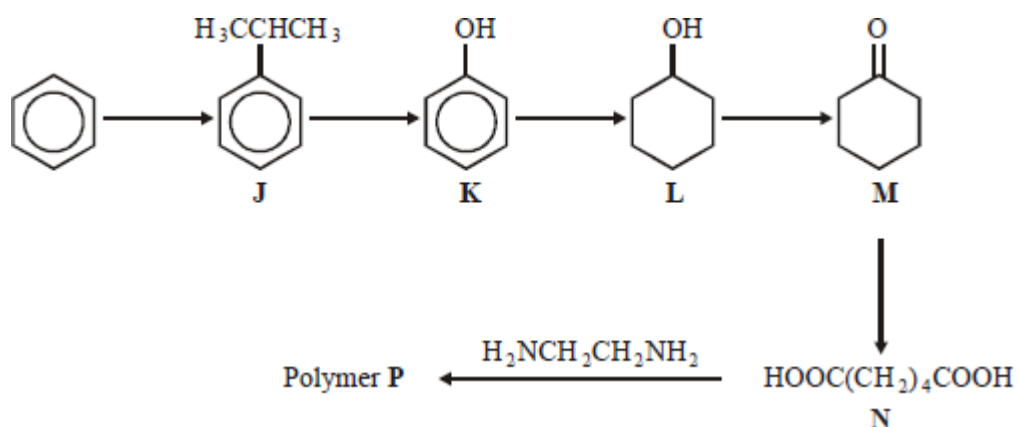
(Total 1 mark)

Q21. Propanoic acid reacts with methanol in the presence of a small amount of concentrated sulphuric acid. The empirical formula of the ester formed is

- A CH_2O
- B $\text{C}_2\text{H}_6\text{O}_2$
- C $\text{C}_2\text{H}_4\text{O}_2$
- D $\text{C}_2\text{H}_4\text{O}$

(Total 1 mark)

Q22. This question is about the following reaction scheme which shows the preparation of polymer P.



If 1.0 kg of benzene gave 0.98 kg of **J**, the percentage yield of **J** was

- A 64
- B 66
- C 68
- D 70

(Total 1 mark)

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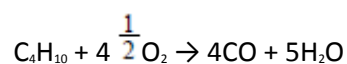
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Q23. A particular sample of iron ore contains 85% by mass of Fe_2O_3 ($M_r = 159.6$) and no other iron compound. The maximum mass of iron that could be extracted from 1.0 tonne of this ore is

- A 0.59 tonne
- B 0.66 tonne
- C 0.75 tonne
- C 0.85 tonne

(Total 1 mark)

Q24. An equation for the incomplete combustion of butane in oxygen is



The volume in dm^3 of oxygen at 295 K and 100 kPa required to burn 0.1 mol of butane to form steam and carbon monoxide only is

- A 8.6
- B 11
- C 12
- C 16

(Total 1 mark)

Q25. The relative molecular mass (M_r) of benzene-1,4-dicarboxylic acid is

- A 164
- B 166
- C 168
- C 170

(Total 1 mark)

Q26. Sodium hydrogencarbonate decomposes on heating as shown by the equation below.



The volume of carbon dioxide, measured at 298 K and 101 kPa, obtained by heating 0.0500 mol of sodium hydrogencarbonate is

- A 613 cm³
- B 1226 cm³
- C 613 dm³
- D 1226 dm³

(Total 1 mark)

Q27. Use the information below to answer this question.

A saturated solution of magnesium hydroxide, Mg(OH)₂, contains 0.1166 g of Mg(OH)₂ in 10.00 dm³ of solution. In this solution the magnesium hydroxide is fully dissociated into ions.

Which one of the following is the concentration of Mg²⁺(aq) ions in the saturated solution?

- A $2.82 \times 10^{-2} \text{ mol dm}^{-3}$
- B $2.00 \times 10^{-3} \text{ mol dm}^{-3}$
- C $2.82 \times 10^{-3} \text{ mol dm}^{-3}$
- D $2.00 \times 10^{-4} \text{ mol dm}^{-3}$

(Total 1 mark)

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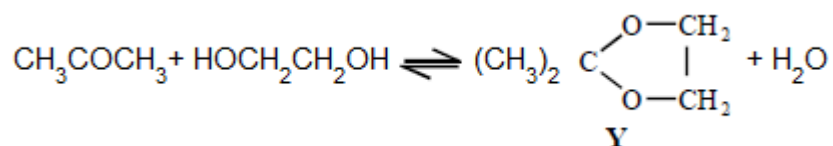
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Q28. Butan-1-ol was converted into butyl propanoate by reaction with an excess of propanoic acid. In the reaction, 6.0 g of the alcohol gave 7.4 g of the ester. The percentage yield of ester was

- A 57
- B 70
- C 75
- D 81

(Total 1 mark)

Q29. This question is about the reaction between propanone and an excess of ethane-1,2-diol, the equation for which is given below.



In a typical procedure, a mixture of 1.00 g of propanone, 5.00 g of ethane-1,2-diol and 0.100 g of benzenesulphonic acid, $\text{C}_6\text{H}_5\text{SO}_3\text{H}$, is heated under reflux in an inert solvent. Benzenesulphonic acid is a strong acid.

If 1.00 g of propanone was vapourised at 100 °C and 100 kPa pressure, the volume in m^3 of gas formed would be

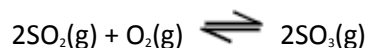
- A 31.0
- B 8.31
- C 0.534
- D 5.34×10^{-4}

(Total 1 mark)

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Q30. This question relates to the equilibrium gas-phase synthesis of sulphur trioxide:



Thermodynamic data for the components of this equilibrium are:

Substance	$\Delta H_f^\ominus / \text{kJ mol}^{-1}$	$S^\ominus / \text{J K}^{-1} \text{mol}^{-1}$
$\text{SO}_3(\text{g})$	-396	+257
$\text{SO}_2(\text{g})$	-297	+248
$\text{O}_2(\text{g})$	0	+204

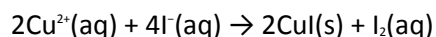
This equilibrium, at a temperature of 585 K and a total pressure of 540 kPa, occurs in a vessel of volume 1.80 dm³. At equilibrium, the vessel contains 0.0500 mol of $\text{SO}_2(\text{g})$, 0.0800 mol of $\text{O}_2(\text{g})$ and 0.0700 mol of $\text{SO}_3(\text{g})$.

At equilibrium in the same vessel of volume 1.80 dm³ under altered conditions, the reaction mixture contains 0.0700 mol of $\text{SO}_3(\text{g})$, 0.0500 mol of $\text{SO}_2(\text{g})$ and 0.0900 mol of $\text{O}_2(\text{g})$ at a total pressure of 623 kPa. The temperature in the equilibrium vessel is

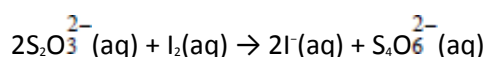
- A 307 °C
- B 596 K
- C 337 °C
- D 642 K

(Total 1 mark)

Q31. The percentage of copper in a copper(II) salt can be determined by using a thiosulphate titration. 0.305 g of a copper(II) salt was dissolved in water and added to an excess of potassium iodide solution, liberating iodine according to the following equation:



The iodine liberated required 24.5 cm³ of a 0.100 mol dm⁻³ solution of sodium thiosulphate:



The percentage of copper, by mass, in the copper(II) salt is

- A 64.2
- B 51.0
- C 48.4
- D 25.5

(Total 1 mark)

Q32. On heating, magnesium reacts vigorously with element **X** to produce compound **Y**. An aqueous solution of **Y**, when treated with aqueous silver nitrate, gives a white precipitate that is readily soluble in dilute aqueous ammonia. What is the minimum mass of **X** that is needed to react completely with 4.05 g of magnesium?

- A 11.83 g
- B 5.92 g
- C 5.33 g
- D 2.67 g

(Total 1 mark)

Q33. 1,3-dinitrobenzene can be prepared by heating nitrobenzene with a mixture of fuming nitric acid and concentrated sulphuric acid. The reaction can be represented by the following equation.



If the yield of the reaction is 55%, the mass of 1,3-dinitrobenzene produced from 12.30 g of nitrobenzene is

- A 16.90 g
- B 16.80 g
- C 9.30 g
- D 9.24 g

(Total 1 mark)

Q34. Which one of the following contains the smallest number of moles of carbon dioxide gas?

- A 2.65 g
- B 0.0150 m³ at 1000 K and 33.0 kPa
- C 1.50 dm³ at 327 °C and 200 kPa
- D 1500 cm³ at 300 K and 100 kPa

(Total 1 mark)

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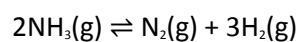
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Q35. Which one of the following compounds contains the smallest percentage, by mass, of oxygen?

- A $\text{CH}_3\text{OCH}_2\text{CH}_3$
- B $\text{CH}_3\text{OCH}_2\text{NH}_2$
- C COS
- D $\text{C}_6\text{H}_9\text{Al}(\text{OH})_2$

(Total 1 mark)

Q36. When one mole of ammonia is heated to a high temperature, 50% dissociates according to the following equilibrium.



What is the total number of moles of gas present in the equilibrium mixture?

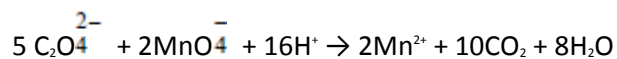
- A 1.5
- B 2.0
- C 2.5
- D 3.0

(Total 1 mark)

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Q37. Aqueous $\text{C}_2\text{O}_4^{2-}$ ions react with MnO_4^- ions in acidic solution according to the equation



Under the same conditions Fe^{2+} ions also react with MnO_4^- ions. How many moles of MnO_4^- ions are required to react exactly with one mole of $\text{Fe}(\text{C}_2\text{O}_4) \cdot 2\text{H}_2\text{O}$?

- A 0.4
- B 0.6
- C 2.5
- D 7.5

(Total 1 mark)

Q38. On complete combustion, 0.0150 mol of an organic acid produced 735 cm³ of carbon dioxide (measured at 101 kPa and 298 K). The same amount of acid required 15.0 cm³ of 2.00 M sodium hydroxide solution for neutralisation. Which one of the following could be the formula of the acid?

- A HCOOH
- B CH₃COOH
- C HOCCOH
- D HOOCCH₂CH₂COOH

(Total 1 mark)

Q39. An excess of methanol was mixed with 12 g of ethanoic acid and an acid catalyst. At equilibrium the mixture contained 8 g of methyl ethanoate. The percentage yield of ester present was

- A 11
- B 20
- C 54
- D 67

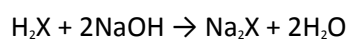
(Total 1 mark)

Q40. Which one of the following samples of gas, when sealed into a vessel of volume 0.10 m³, is at the highest pressure?

- A 1.6 g of helium (He) at 100 K
- B 1.6 g of methane (CH₄) at 100 K
- C 1.6 g of oxygen (O₂) at 600 K
- D 1.6 g of sulphur dioxide (SO₂) at 1200 K

(Total 1 mark)

Q41. In a titration, 0.52 g of a diprotic acid, H₂X, reacts exactly with 100 cm³ of 0.10 M sodium hydroxide.



The acid could be

- A ethanedioic
- B propanedioic
- C butanedioic
- D pentanedioic

(Total 1 mark)

Q42. 0.00125 mol of a compound was heated with an excess of a solution of potassium hydroxide and the ammonia evolved required 17.0 cm³ of 0.220 M hydrochloric acid for neutralisation. Which one of the following could be the formula of this compound?

- A BF₃NH₃
- B VCl₃(NH₃)₃
- C CrCl₂(NH₃)₂
- D [Be(NH₃)₄]Cl₂

(Total 1 mark)

Q43. What is the volume occupied by 10.8 g of the freon CCl₂F₂ at 100 kPa and 273 K?

- A 2.02 dm³
- B 2.05 dm³
- C 2.02 cm³
- D 2.05 cm³

(Total 1 mark)

Q44. Which one of the following contains the greatest number of moles of methanol? (The Avogadro number (L) is 6.02×10^{23} , the relative molecular mass (M_r) of methanol is 32.)

- A 6.6×10^{22} molecules
- B 3.3 g of methanol
- C 2.5×10^{-3} m³ of methanol vapour at 300 K and 100 kPa
- D 70 cm³ of 1.5 M aqueous methanol

(Total 1 mark)

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Q45. An alkane contains 30 hydrogen atoms per molecule. Its empirical formula is

- A C_6H_{15}
- B C_7H_{15}
- C $C_{14}H_{30}$
- D $C_{15}H_{30}$

(Total 1 mark)

Q46. Hydrolysis of the ester, $CH_3COOCH_2CH_2CH_3$, produces ethanoic acid. In an experiment, 2.04 g of the ester was used and 0.90 g of ethanoic acid was produced. The percentage yield of ethanoic acid was:

- A 44
- B 59
- C 75
- D 90

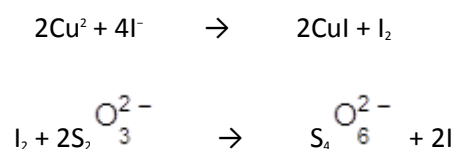
(Total 1 mark)

Q47. Which one of the following samples of gas occupies the largest volume?

- A 1.0 g of ozone (O_3) at 100 kPa and 300 K
- B 1.0 g of oxygen at 100 kPa and 300 K
- C 1.0 g of water vapour at 250 kPa and 450 K
- D 1.0 g of methane at 333 kPa and 500 K

(Total 1 mark)

Q48. Copper(II) ions can be estimated volumetrically by the addition of an excess of potassium iodide followed by titration of the liberated iodine with sodium thiosulphate solution. The following equations apply:



What volume (in cm^3) of 0.1 M $\text{Na}_2\text{S}_2\text{O}_3$ would be required to react with the iodine produced from 1.249 g of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ (M_r 249.7)?

- A 10
- B 25
- C 50
- D 100

(Total 1 mark)

Q49. A “drink-driving” offence is committed if the blood alcohol level of a driver is over 80 mg of ethanol per 100 cm^3 of blood.

What is the concentration (in mol dm^3) of ethanol if there are 80 mg of ethanol per 100 cm^3 of blood?

- A 0.0017
- B 0.017
- C 0.080
- D 0.80

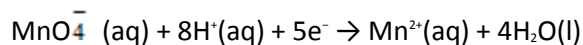
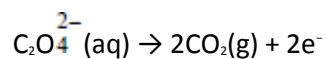
(Total 1 mark)

Q50. When vanadium reacts with chlorine at 400°C, a brown compound is obtained. When an aqueous solution containing 0.193 g of this compound was treated with aqueous silver nitrate all the chlorine in the compound was precipitated as silver chloride. The mass of silver chloride (AgCl) produced was 0.574 g. Which one of the following could be the formula of the brown compound?

- A VCl
- B VCl₂
- C VCl₃
- D VCl₄

(Total 1 mark)

Q51. The oxidation of ethanedioate (*oxalate*) ions by manganate(VII) ions can be represented by the half equations:



What volume (in cm³) of 0.02 M KMnO₄ is required to oxidise completely a solution containing 0.02 mol of ethanedioate ions?

- A 25
- B 40
- C 250
- D 400

(Total 1 mark)

Q52. CH₂O is the empirical formula of

- A methanol
- B methyl methanoate
- C ethane-1,2-diol
- D butanal

(Total 1 mark)

Q53. When TiCl₄ is reduced with hydrogen under certain conditions, a new compound is produced which contains 68.9% chlorine by mass. Which one of the following could be the formula of the new compound?

- A TiH₂Cl₂
- B TiCl
- C TiCl₂
- D TiCl₃

(Total 1 mark)

Q54. A brand of fluoride tablets, recommended by a dentist to strengthen the enamel on teeth, contains 2.2×10^{-3} sodium fluoride per tablet. The total mass of fluoride ion present in 100 tablets is

- A $2.2 \times 10^{-3} \times \frac{19}{42} \times 100$
- B $2.2 \times 10^{-3} \times \frac{19}{23} \times 100$
- C $2.2 \times 10^{-3} \times \frac{9}{20} \times 100$
- D $\frac{100 \times 19}{2.2 \times 10^{-3}}$

(Total 1 mark)