Q1. Potassium nitrate, KNO_3, decomposes on strong heating, forming oxygen and solid **Y** as the only products.

(a) A 1.00 g sample of KNO_3 (M_r = 101.1) was heated strongly until fully decomposed into **Y**.

(i) Calculate the number of moles of KNO_3 in the 1.00 g sample.

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....

(ii) At 298 K and 100 kPa, the oxygen gas produced in this decomposition occupied a volume of 1.22×10^{-4} m^3.

State the ideal gas equation and use it to calculate the number of moles of oxygen produced in this decomposition.
(The gas constant R = 8.31 J K^{-1} mol^{-1})

Ideal gas equation ....

Moles of oxygen ....

....

....

....

....

(5)

(b) Compound **Y** contains 45.9% of potassium and 16.5% of nitrogen by mass, the remainder being oxygen.

(i) State what is meant by the term *empirical formula*.

....

....

(ii) Use the data above to calculate the empirical formula of **Y**.

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(4)

(c) Deduce an equation for the decomposition of KNO_3 into **Y** and oxygen.

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(1)
(Total 10 marks)

Q2. 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

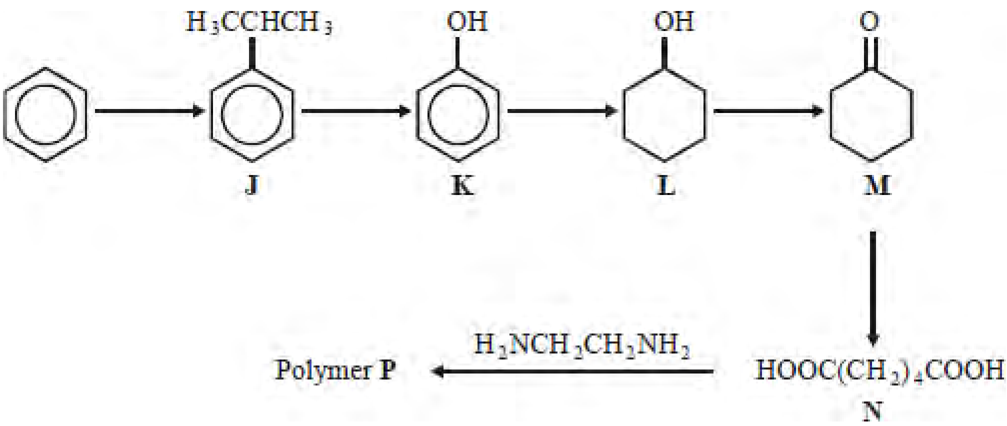
B 0.66 tonne

C 0.75 tonne

C 0.85 tonne

(Total 1 mark)

Q3. 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)

Q4. 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 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)

Q5. The percentage by mass of carbon is 83.3% in

A propane.

B butane.

C pentane.

D hexane.

(Total 1 mark)

Q6. (a) Ammonium sulphate reacts with aqueous sodium hydroxide as shown by the equation below.

$$(NH_4)_2SO_4 + 2NaOH \rightarrow 2NH_3 + Na_2SO_4 + 2H_2O$$

A sample of ammonium sulphate was heated with 100 cm^3 of 0.500 mol dm^{-3}

aqueous sodium hydroxide. To ensure that all the ammonium sulphate reacted, an excess of sodium hydroxide was used.
Heating was continued until all of the ammonia had been driven off as a gas.
The unreacted sodium hydroxide remaining in the solution required 27.3 cm^3 of 0.600 mol dm^{-3} hydrochloric acid for neutralisation.

(i) Calculate the original number of moles of NaOH in 100 cm^3 of 0.500 mol dm^{-3} aqueous sodium hydroxide.

....

....

(ii) Calculate the number of moles of HCl in 27.3 cm^3 of 0.600 mol dm^{-3} hydrochloric acid.

....

....

(iii) Deduce the number of moles of the unreacted NaOH neutralised by the hydrochloric acid.

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(iv) Use your answers from parts (a) (i) and (a) (iii) to calculate the number of moles of NaOH which reacted with the ammonium sulphate.

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....

(v) Use your answer in part (a) (iv) to calculate the number of moles and the mass of ammonium sulphate in the sample.
(If you have been unable to obtain an answer to part (a) (iv), you may assume that the number of moles of NaOH which reacted with ammonium sulphate equals 2.78×10^{-2} mol. This is not the correct answer.)

Moles of ammonium sulphate ....

....

Mass of ammonium sulphate ....

....

(7)

(b) A 0.143g gaseous sample of ammonia occupied a volume of 2.86×10^{-4} m^3 at a temperature ***T*** and a pressure of 100 kPa.

State the ideal gas equation, calculate the number of moles of ammonia present and deduce the value of the temperature ***T***.

(The gas constant R = 8.31 J K^{-1} mol^{-1})

Ideal gas equation ....

Moles of ammonia ....

....

*Value of **T*** ....

....

....

....

....

(4)
(Total 11 marks)

Q7. 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)

Q8. 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)

Q9. 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)

Q10. (a) Lead(II) nitrate may be produced by the reaction between nitric acid and lead(II) oxide as shown by the equation below.

$PbO + 2HNO_3 \rightarrow Pb(NO_3)_2 + H_2O$

An excess of lead(II) oxide was allowed to react with 175 cm^3 of 1.50 mol dm^{-3} nitric acid. Calculate the maximum mass of lead(II) nitrate which could be obtained from this reaction.

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....

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....

....

(4)

(b) An equation representing the thermal decomposition of lead(II) nitrate is shown below.

$2Pb(NO_3)_2(s) \rightarrow 2PbO(s) + 4NO_2(g) + O_2(g)$

A sample of lead(II) nitrate was heated until the decomposition was complete. At a temperature of 500 K and a pressure of 100 kPa, the total volume of the gaseous mixture produced was found to be 1.50×10^{-4} m^3.

(i) State the ideal gas equation and use it to calculate the total number of moles of gas produced in this decomposition.
(The gas constant R = 8.31 J K^{-1} mol^{-1})

Ideal gas equation ....

Total number of moles of gas ....

....

....

....

(ii) Deduce the number of moles, and the mass, of NO_2 present in this gaseous mixture. (If you have been unable to calculate the total number of moles of gas in part (b)(i), you should assume this to be 2.23×10^{-3} mol. This is not the correct answer.)

Number of moles of NO_2 ....

....

Mass of NO_2 ....

....

(7)
(Total 11 marks)

Q11. (a) Name and outline a mechanism for the reaction between propanoyl chloride, CH_3CH_2COCl, and methylamine, CH_3NH_2
Draw the structure of the organic product.

(6)

(b) Benzene reacts with propanoyl chloride in the presence of aluminium chloride.
Write equations to show the role of aluminium chloride as a catalyst in this reaction.
Outline a mechanism for this reaction of benzene.

(5)

(c) Write an equation for the reaction of propanoyl chloride with water. An excess of water is added to 1.48 g of propanoyl chloride. Aqueous sodium hydroxide is then added from a burette to the resulting solution.
Calculate the volume of 0.42 mol dm^{-3} aqueous sodium hydroxide needed to react exactly with the mixture formed.

(5)
(Total 16 marks)