Q1.

What is the percentage atom economy for the production of ethanol from glucose?

$$C_6H_{12}O_6 \rightarrow 2\ C_2H_5OH + 2\ CO_2$$

A 25.6% ○

B 27.1% ○

C 51.1% ○

D 54.2% ○

(Total 1 mark)

Q2.

Propene can be made by the dehydration of propan-2-ol.

What is the percentage yield when 30 g of propene (M_r = 42.0) are formed from 50 g of propan-2-ol (M_r = 60.0)?

A 60% ○

B 67% ○

C 81% ○

D 86% ○

(Total 1 mark)

Q3.

A student completes a titration to determine the concentration of ethanoic acid in vinegar.

25.0 cm^3 of vinegar are transferred to a conical flask using a pipette.
A few drops of phenolphthalein are added to the conical flask.
Sodium hydroxide solution is added from a burette to the conical flask.
The titration is repeated until concordant results are obtained.

Which suggestion decreases the percentage uncertainty in the mean titre?

A Use a more dilute solution of sodium hydroxide in the burette. ○

B Use a more dilute solution of vinegar. ○

C Rinse the inside of the conical flask with distilled water during each titration. ○

D Rinse the tip of the burette with distilled water near the end point in each titration. ○

(Total 1 mark)

Q4.

An ester is hydrolysed as shown by the following equation.

$$RCOOR' + H_2O \longrightarrow RCOOH + R'OH$$

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)

Q5.

A student completes a titration to determine the concentration of ethanoic acid in vinegar.

25.0 cm^3 of vinegar are transferred to a conical flask using a pipette.
A few drops of phenolphthalein are added to the conical flask.
Sodium hydroxide solution is added from a burette to the conical flask.
The titration is repeated until concordant results are obtained.

Which suggestion improves the accuracy of the titres?

A Rinsing the conical flask with vinegar between each titration. ⬭

B Rinsing the conical flask with sodium hydroxide solution between each titration. ⬭

C Rinsing the conical flask with water between each titration. ⬭

D Not rinsing the conical flask between each titration. ⬭

(Total 1 mark)

Q6.

What is the percentage yield when 20 g of aluminium are produced from 50 g of aluminium oxide?

$$2Al_2O_3 \rightarrow 4Al + 3O_2$$

A 76% ⬭

B 40% ⬭

C 33% ⬭

D 19% ⬭

(Total 1 mark)

Q7.

Ethanol can be made from glucose by fermentation.

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

In an experiment, 268 g of ethanol (M_r = 46.0) were made from 1.44 kg of glucose (M_r = 180.0).

What is the percentage yield?

A 18.6% ⬭

B 36.4% ⬭

C 51.1% ⬭

D 72.8% ⬭

(Total 1 mark)

Q8.

A volumetric flask was used to prepare 250 cm^3 of a solution.

The solute was added from a plastic weighing container.

	Mass / g
Weighing container with solute	10.13
Weighing container after solute added to volumetric flask	4.48

Each reading from the balance has an uncertainty of ±0.005 g

What is the percentage uncertainty in the mass of the solute used?

A 0.09% ⬭

B 0.11% ⬭

C 0.18% ⬭

D 0.22% ⬭

(Total 1 mark)

Q9.

What is the atom economy for the formation of ethylamine in this reaction?

$$CH_3CH_2Br + 2\ NH_3 \rightarrow CH_3CH_2NH_2 + NH_4Br$$

A 31.5%

B 35.7%

C 36.1%

D 41.3%

(Total 1 mark)

Q10.

N-phenylethanamide is used as an inhibitor in hydrogen peroxide decomposition and also in the production of dyes.

N-phenylethanamide can be produced in a laboratory by the reaction between phenylammonium sulfate and an excess of ethanoic anhydride:

(a) A student carried out this preparation using 1.15 g of phenylammonium sulfate (M_r = 284.1) and excess ethanoic anhydride.

$$(C_6H_5NH_3)_2SO_4 + 2(CH_3CO)_2O \rightarrow 2C_6H_5NHCOCH_3 + 2CH_3COOH + H_2SO_4$$

(i) Calculate the maximum theoretical yield of N−phenylethanamide that could be produced in the reaction. Record your answer to an appropriate precision.

Show your working.

____

____

____

____

____

____

(3)

(ii) In the preparation, the student produced 0.89 g of N−phenylethanamide.

Calculate the percentage yield for the reaction.

(1)

(b) The student purified the crude solid product, N−phenylethanamide, by recrystallisation.

(i) Outline the method that the student should use for this recrystallisation.

(4)

(ii) Outline how you would carry out a simple laboratory process to show that the recrystallised product is a pure sample of N−phenylethanamide.

(3)

(iii) Assume that the reaction goes to completion.

Suggest **two** practical reasons why the percentage yield for this reaction may **not** be 100%.

1. ______________________________

____

2. ______________________________

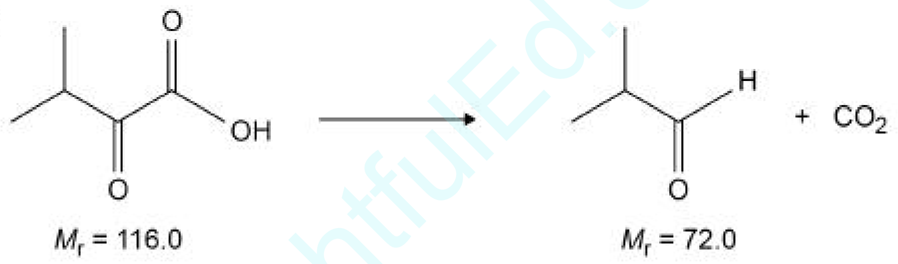
____

(2)

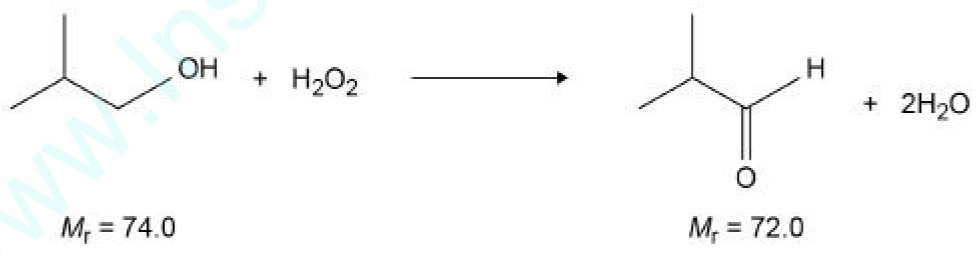
Q11.

A student investigates two experimental methods of making methylpropanal. The equations for these two methods are shown.

Method 1



Method 2



In each method, the student uses 1.00 g of organic starting material.

The yield of methylpropanal obtained using each method and other data are included in the table.

	Method 1	**Method 2**
Yield of methylpropanal / mg	552	778
Percentage yield		80.0%
Percentage atom economy	62.1%	

Calculate the percentage yield for Method 1.

Calculate the percentage atom economy for Method 2.

State the importance of percentage yield and percentage atom economy when choosing the method used to make a compound.

% yield _______________

Importance of percentage yield ____

____

____

____

____

% atom economy _______________

Importance of percentage atom economy ____________________________________

____

____

____

____

(Total 6 marks)

Q12.

Ethyl ethanoate can be made by reacting ethanol with ethanoic acid in the presence of concentrated sulfuric acid.

Method

1. A mixture of ethanol, ethanoic acid, and concentrated sulfuric acid, with anti-bumping granules, is heated under reflux for 10 minutes.
2. The apparatus is rearranged for distillation.
3. The mixture is heated to collect the liquid that distils between 70 and 85 °C
4. The distillate is placed in a separating funnel. Aqueous sodium carbonate is added, and a stopper is placed in the funnel. The mixture is shaken, releasing pressure as necessary.
5. The lower aqueous layer is removed and the upper organic layer is placed in a small conical flask.
6. Anhydrous calcium chloride is added to the sample in the conical flask. The flask is shaken well and left for a few minutes.
7. The liquid from the flask is redistilled and the distillate is collected between 74 and 79 °C

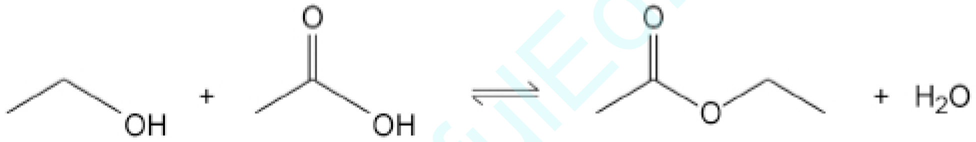
(a) State the role of concentrated sulfuric acid in this reaction.

____

____

(1)

(g) A student uses the method to prepare some ethyl ethanoate.



The student adds 10.0 cm^3 of ethanol (M_r = 46.0) to 5.25 g of ethanoic acid (M_r = 60.0) and obtains 5.47 g of ethyl ethanoate (M_r = 88.0).

For ethanol, density = 0.790 g cm^{-3}

Determine the limiting reagent.

Calculate the percentage yield of ethyl ethanoate.

Limiting reagent ____________________

Percentage yield ____________________

(5)

(h) Suggest a reason why the percentage yield is **not** 100%.

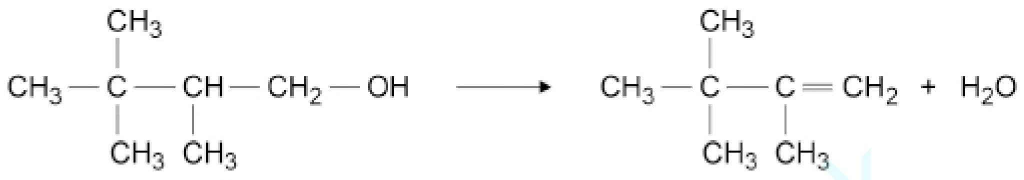
____

____

(1)

Q13.

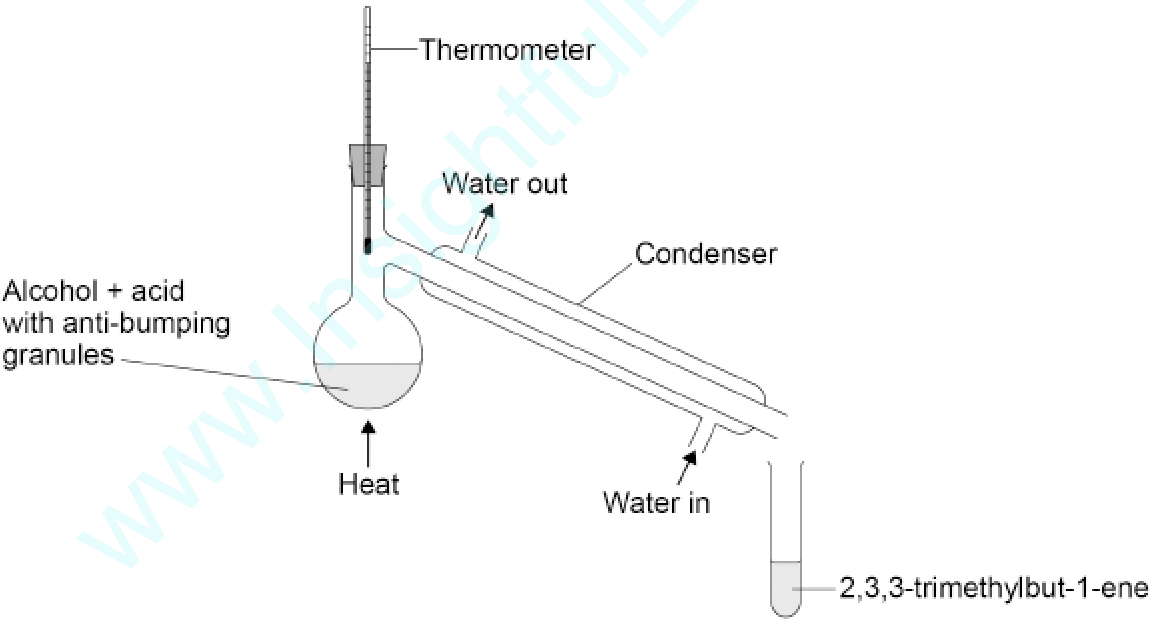
This question is about the preparation of 2,3,3-trimethylbut-1-ene.



2,3,3-trimethylbutan-1-ol 2,3,3-trimethylbut-1-ene

The preparation is done by heating the alcohol with concentrated phosphoric acid, that acts as a catalyst.

The figure below shows the apparatus used.



The distillate is collected in the range 77–82 °C

(c) In a similar experiment, 12.0 cm^3 of 2,3,3-trimethylbutan-1-ol (M_r = 116.0) produces 6.12 g of 2,3,3-trimethylbut-1-ene.

Calculate the percentage yield.

density of 2,3,3-trimethylbutan-1-ol = 0.818 g cm^{-3}

Percentage yield ______________________ **(5)**

Q14.

A student prepared cyclohexene by heating cyclohexanol with concentrated phosphoric acid. The cyclohexene produced was distilled off from the reaction mixture.

(d) In this preparation, the student added an excess of concentrated phosphoric acid to 14.4 g of cyclohexanol (M_r = 100.0).
The student obtained 4.15 cm^3 of cyclohexene (M_r = 82.0).
Density of cyclohexene = 0.810 g cm^{-3}

Calculate the percentage yield of cyclohexene obtained.
Give your answer to the appropriate number of significant figures.

% yield ___________________________

(5)

Q15.

Trichlorofluoromethane (CCl_3F) was developed as a refrigerant. The production and use of CCl_3F is now restricted.

(a) The equation for a process used to manufacture CCl3F is

$$SbF_3Br_2 + CCl_4 \rightarrow CCl_3F + SbF_2Br_2Cl$$

Calculate the percentage atom economy for the production of CCl_3F in this reaction. Give your answer to 3 significant figures.

Percentage atom economy ________________

(2)

Q16.

Phosphoric(V) acid (H_3PO_4) is an important chemical. It can be made by two methods. The first method is a two-step process.

(a) In the first step of the first method, phosphorus is burned in air at 500 ºC to produce gaseous phosphorus(V) oxide.

$$P_4(s) \quad + \quad 5O_2(g) \quad \longrightarrow \quad P_4O_{10}(g)$$

220 g of phosphorus were reacted with an excess of air.

Calculate the volume, in m^3, of gaseous phosphorus(V) oxide produced at a pressure of 101 kPa and a temperature of 500 ºC.
The gas constant R = 8.31 J K^{-1} mol^{-1}
Give your answer to 3 significant figures.

(4)

(b) In the second step of the first method, phosphorus(V) oxide reacts with water to form phosphoric(V) acid.

$$P_4O_{10}(s) \quad + \quad 6H_2O(l) \quad \longrightarrow \quad 4H_3PO_4(aq)$$

Calculate the mass of phosphorus(V) oxide required to produce 3.00 m^3 of 5.00 mol dm^{-3} phosphoric(V) acid solution.

(3)

(c) In the second method to produce phosphoric(V) acid, 3.50 kg of $Ca_3(PO_4)_2$ are added to an excess of aqueous sulfuric acid.

$$Ca_3(PO_4)_2(s) \quad + \quad 3H_2SO_4(aq) \quad \longrightarrow \quad 2H_3PO_4(aq) \quad + \quad 3CaSO_4(s)$$

1.09 kg of phosphoric(V) acid are produced.

Calculate the percentage yield of phosphoric(V) acid.

(4)

(d) Explain whether the first method or the second method of production of phosphoric acid has the higher atom economy.
You are not required to do a calculation.

(1) (Total 12 marks)

Mark schemes

Q1.

C

51.1%

[1]

Q2.

D

[1]

Q3.

A

Use a more dilute solution of sodium hydroxide in the burette.

[1]

Q4.

D

[1]

Q5.

C

Rinsing the conical flask with water between each titration.

[1]

Q6.

A

[1]

Q7.

B

[1]

Q8.

C

[1]

Q9.

A

31.5%

[1]

Q10.

(a) (i) M_r N−phenylethanamide = 135.0 **1**

Theoretical yield = 135.0 × 2 (1.15 / 284.1) = 1.09 g **1**

Answer recorded to 3 significant figures. **1**

(ii) $\frac{0.89}{\text{Ans to (a)}}$ × 100

= 81.4 %

Mark consequentially to (a)
Allow 81 to 82 **1**

(b) (i) Dissolve the product in the **minimum** volume of water / solvent (in a boiling tube / beaker)

If dissolving is not mentioned, CE = 0 / 4 **1**

<u>Hot</u> water / solvent

Steps must be in a logical order to score all 4 marks **1**

Allow the solution to cool and allow crystals to form. **1**

Filter off the pure product under reduced pressure / using a Buchner funnel and side arm flask

Ignore source of vacuum for filtration (electric pump, water pump, etc.) **1**

(ii) Measure the melting point **1**

Use of melting point apparatus or oil bath **1**

Sharp melting point / melting point matches data source value **1**

(iii) Any **two** from:

Product left in the beaker or glassware
Sample was still wet
Sample lost during recrystallisation.

Do not allow "sample lost" without clarification. **2 Max**

Q11.

Percentage yield

M1 reactant moles = $\frac{1.00}{116.0}$ (= 0.00862)

*Correct **M3** scores **M1-3***

Numerical answers to at least 2sf

*Allow ECF in **M1-M3***

1

M2 product moles = $\frac{0.552}{72.0}$ (= 0.00767)

Alternative for M2/3

***M2** expected mass of product = 0.00862 x 72.0 (= 0.621 g)*

1

M3 % yield = $\frac{0.00767}{0.00862}$ = 88.9(3) or 89%

Alternative for M2/3

***M3** % yield = ($\frac{0.552}{0.621}$ x 100) = 88.9(3) or 89%*

1

M4 idea of getting as much product as possible in the reaction / idea of efficient conversion of reactants to products

1

Atom economy

M5 $\left(\frac{72.0}{74.0+34.0} x\ 100\right) = \left(\frac{72.0}{108.0} x\ 100\right) = 66.7\%$

Alternative for M5: $\left(\frac{72.0}{72.0+36.0} x\ 100\right)$

1

M6 idea of maximising the mass of reactants / atoms that ends up in desired product or idea of minimising the amount of by-products

1

[6]

Q12.

(a) catalyst

***ALLOW** reduces E_a*

***IGNORE** speeds up reaction*

***IGNORE** provides alternative path*

***IGNORE** proton donor*

***IGNORE** dehydrating agent*

1

(g) **M1** mass of ethanol = 10 x 0.790 (= 7.90 g)

M2 amount of ethanol = $\frac{7.90}{46.0}$ (= 0.172 mol) **AND**

amount of ethanoic acid = $\frac{5.25}{60.0}$ (= 0.0875 mol)

M3 (limiting reagent is) ethanoic acid

M4 (max amount of ethyl ethanoate = 0.0875 mol)

max mass of ethyl ethanoate = 88.0 x 0.0875 (= 7.70 g)

M5 % yield = $\frac{5.47}{\text{M4}}$ x 100 = 71.0% (70.6 to 71.1 to min 2sf)

Allow ECF at each stage

***M1** scores from 0.172 mol of ethanol*

***M2** need to see numbers or sums for both substances*

***M2** 10/46 can only be ECF if 10 is identified as a mass*

***M3** ECF from **M2** if both amounts clearly shown and $n_{ethanol} < n_{ethanoic\ acid}$*

M4** independent of **M3

*Alternative **M4 & 5***

***M4** Amount of ethyl ethanoate formed*

= $\frac{5.47}{88.0}$ *(=0.0622)*

***M5** % yield =* $\frac{\text{M4}}{0.0875}$ *x 100 = 71.0%*

Correct answer scores M4 and M5 but mark M1/2/3 separately

***M5** must show an attempt at mass or moles of ester formed divided by mass or moles of ester expected*

5

(h) reaction is an equilibrium/reversible

***ALLOW** losses during distillation/isolation/purification/transfer / incomplete distillation / side reactions / byproducts*

***ALLOW** incomplete reaction*

***ALLOW** impurities/contamination/water present / not dry*

***IGNORE** water is also produced (during the reaction)*

1

[17]

Q13.

(c) Correct answer scores 5

M1 mass of alcohol = 12 × 0.818 (= 9.816 g)

M2 amount of alcohol = $\frac{\text{M1}}{116(.0)}$ (= 0.0846 mol)

M3 M_r of alkene = 98(.0)

M4 mass of alkene expected = **M2** × **M3** (= 8.29 g)

M5 % yield = $\frac{6.12}{\text{M4}}$ × 100 = 73.8% (at least 2sf)

Alternative

M4 *mol of alkene formed =* $\frac{6.12}{\text{M3}}$ *(= 0.0624 mol)*

M5 *% yield =* $\frac{\text{M4}}{\text{M2}}$ *× 100 = 73.8% (at least 2sf)*

Allow ECF at each stage

M5 *should be an attempt at (their) mass (or moles) of alkene achieved divided by their mass (or moles) of alkene expected x 100*

5

[11]

Q14.

(d)

Via moles	*Via mass*	*Via volume*	
Amount cyclohexanol (= 14.4/100) = 0.144 mol	Amount cyclohexanol (= 14.4/100) = 0.144 mol	Amount cyclohexanol (= 14.4/100) = 0.144 mol	**M1**
Mass cyclohexene formed = 4.15 x 0.81 = 3.36 g	Mass cyclohexene formed = 4.15 x 0.81 = 3.36 g	Mass of cyclohexene expected (= 0.144 × 82.0 = 11.808 g) OR M1 × 82	**M2**
amount cyclohexene obtained (= 3.36/82.0 = 0.0410 mol) OR M2/82.0	mass of cyclohexene expected (= 0.144 × 82.0 = 11.808 g) OR = M1 × 82.0	volume of cyclohexene expected (= 11.808/0.810 = 14.577cm^3) OR M2/0.810	**M3**
%Yield = $\frac{0.0410}{0.144}$ x 100 OR $\frac{\text{M3}}{\text{M1}}$ x 100	%Yield = $\frac{3.36}{11.808}$ x 100 OR $\frac{\text{M2}}{\text{M3}}$ x 100	%Yield = $\frac{4.15}{14.577}$ x 100 OR $\frac{4.15}{\text{M3}}$ x 100	**M4**
= 28.5% (must be 3 sf)	= 28.5% (must be 3 sf)	= 28.5% (must be 3 sf)	

Only award M5 if answer is to 3sf and follows some attempt at % yield calculation in M4	**M5**

Q15.

(a) **M1** $\frac{137.5}{492.6}$ or

$$\frac{12.0 + 3(35.5) + 19.0}{121.8 + 3(19.0) + 2(79.9) + 12.0 + 4(35.5)} \text{ or } \frac{137.5}{338.6 + 154.0}$$

$$\frac{12.0 + 3(35.5) + 19.0}{12.0 + 3(35.5) + 19.0 + 121.8 + 2(19.0) + 2(79.9) + 35.5} \text{ or } \frac{137.5}{355.1 + 137.5}$$

1

M2 (× 100) = 27.9 (%)

1

***M2** must be 3 sig figs*

Correct answer scores 2 marks

Can score 1 mark for 137.5 (or working that gives this) or 492.6 (or working that gives this) in working if no other marks scored

Q16.

(b) No moles H_3PO_4 = 3 × 10^3 (dm^3) × 5 = 15,000 (mols)

Correct answer with or without working scores 3 marks

If M1 incorrect then can only score M2

1

No moles phosphorus(V) oxide = $\frac{15000}{4}$ (= 3,750 mols)

$M2 = \frac{M1}{4}$ (process)

If M2 incorrect can only score M1

1

1.1 × 10^6 or1.07 × 10^6 or 1.065 × 10^6 (g)
or 1,100 or 1,070 or 1065 kg
or 1.1 or 1.07 or 1.065 tonne

= (3.75 × 10^3 × 284.0)

Min 2 sig fig

1

(c) No moles $Ca_3(PO_4)_2$ (= 3.50kg =) $\frac{3500\text{ g}}{310(.3)}$ = 11.28

Correct answer with or without working scores 4 marks

If M1 incorrect can only score M2 and M3

1

Theoretical No. moles H_3PO_4 = 11.28 × 2 = 22.56

If M2 incorrect can only score M1 and M3

1

Theoretical mass H_3PO_4 = 22.56 × 98(.0) = 2211

If M3 incorrect can only score M1and M2

1

or Actual No. moles H_3PO_4 produced = $\frac{1090}{98}$ = 11.12

<u>49 – 49(.312) (%)</u>

$(\% \text{ yield (moles)} = (\frac{11.12}{22.56} \times 100)$

$\text{or } (\% \text{ yield (mass)} = (\frac{1090}{2211} \times 100)$

1

(d) Method 1 / (a) & (b) because only one product / no other products formed / atom economy = 100% (even though two steps)

Allow calculations

Do not allow if P_2O_5 is formed

Allow converse explanation

1

[12]