Surname	StemUp Model Solution	Centre Number	Candidate Number
First name(s)			2

GCE A LEVEL

A410U30-1

S25-A410U30-1

FRIDAY, 20 JUNE 2025 – MORNING

CHEMISTRY – A level component 3

Chemistry in Practice

1 hour 15 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**11**	
2.	**19**	
3.	**19**	
4.	**11**	
Total	**60**	

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ADDITIONAL MATERIALS

- A calculator, pencil and ruler
- **Data Booklet** supplied by WJEC

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 60.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The assessment of the quality of extended response (QER) will take place in **Q3**(a).

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Answer **all** questions.

1. The following method was used to compare the rate of hydrolysis of 1-chlorobutane, 1-bromobutane and 1-iodobutane.

- Three test tubes containing a mixture of ethanol and acidified silver nitrate were placed in a 50 °C water bath
- Five drops of 1-chlorobutane were added to one of the test tubes and a stopwatch was started
- The time taken to form a precipitate was recorded
- The method was repeated with 1-bromobutane and 1-iodobutane

(a) (i) Record the colours of the precipitates formed in the table below. [1]

Halogenoalkane	Colour of precipitate	Time taken to form precipitate / s
1-chlorobutane	white	606
1-bromobutane	cream	87
1-iodobutane	(pale) yellow	52

(ii) I. Name the type of reaction mechanism for the hydrolysis of these halogenoalkanes. [1]

nucleophilic substitution

II. Explain the trend in the rate of the reaction. [1]

The rate increases from Cl to Br to I because the C–Hal bond becomes progressively weaker (lower bond enthalpy), so it is more easily broken.

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(b) The following data was obtained for the alkaline hydrolysis of two different halogenoalkanes at 20 °C.

(i) Use the data in the tables to deduce the rate equation for both reactions.

Give your reasoning. [4]

$CH_3(CH_2)_3Cl$			
Experiment	Initial concentration / mol dm^{-3}		Initial rate / mol dm^{-3} s^{-1}
	$CH_3(CH_2)_3Cl$	OH^-	
A	0.18	0.22	5.94×10^{-6}
B	0.54	0.22	1.78×10^{-5}
C	0.18	0.44	1.19×10^{-5}
D	1.80		5.94×10^{-4}

A and B: $[OH^-]$ constant, $[CH_3(CH_2)_3Cl]$ × 3 and rate × 3, so first order with respect to $CH_3(CH_2)_3Cl$.

A and C: $[CH_3(CH_2)_3Cl]$ constant, $[OH^-]$ doubled and rate doubles, so first order with respect to OH^-.

rate = *$k\,[CH_3(CH_2)_3Cl]\,[OH^-]$*

$(CH_3)_3CCl$			
Experiment	Initial concentration / mol dm^{-3}		Initial rate / mol dm^{-3} s^{-1}
	$(CH_3)_3CCl$	OH^-	
E	0.15	0.15	6.75×10^{-6}
F	0.60	0.15	2.70×10^{-5}
G	0.45	0.45	2.03×10^{-5}

E and F: $[OH^-]$ constant, $[(CH_3)_3CCl]$ × 4 and rate × 4, so first order with respect to $(CH_3)_3CCl$.

E and G: both concentrations × 3 but rate only × 3, so zero order with respect to OH^-.

rate = *$k\,[(CH_3)_3CCl]$*

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(ii) Deduce the concentration of OH^- in experiment **D**. [1]

D: rate × 100 compared with A, $[CH_3(CH_2)_3Cl]$ × 10

so $[OH^-]$ must also be × 10: 0.22 × 10 = 2.20

Concentration = 2.20 mol dm^{-3}

(iii) Calculate the value of the rate constant, *k*, for the alkaline hydrolysis of $CH_3(CH_2)_3Cl$. Give its unit. [3]

k = rate ÷ $([CH_3(CH_2)_3Cl]\ [OH^-])$

using A: $k = 5.94 \times 10^{-6} \div (0.18 \times 0.22)$

$k = 5.94 \times 10^{-6} \div 0.0396 = 1.50 \times 10^{-4}$

units: mol dm^{-3} s^{-1} ÷ $(mol\ dm^{-3})^2$ = mol^{-1} dm^3 s^{-1}

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Value of *k* = 1.50×10^{-4}

Unit mol^{-1} dm^3 s^{-1}

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2. A student determined the purity of a sample of 1-bromobutane by two different methods.

The student started by dissolving 11.624 g of the 1-bromobutane sample in a mixture of ethanol and water in a conical flask. They added 100 cm^3 of 2.80 mol dm^{-3} sodium hydroxide solution (an excess). The mixture was swirled to ensure complete reaction.

$$C_4H_9Br + NaOH \longrightarrow C_4H_9OH + NaBr$$

The mixture was transferred quantitatively to a 250 cm^3 volumetric flask and the volume made up to the mark with deionised water.

The mixture was labelled as solution **X**.

Method 1: Titration

The student pipetted a 25.0 cm^3 sample of solution **X** into a conical flask and titrated it against 0.980 mol dm^{-3} hydrochloric acid. This was repeated and the following results were recorded.

	1	**2**	**3**	**4**
Final burette reading / cm^3	23.95	25.30	22.35	23.75
Initial burette reading / cm^3	2.30	4.95	2.20	3.50
Titre / cm^3	21.65	20.35	20.15	20.25

Method 2: Gravimetric analysis

The student added a 100 cm^3 sample of solution **X** to a beaker. Dilute nitric acid was added to neutralise hydroxide ions remaining from the preparation of the solution and preventing the formation of silver hydroxide.

Excess aqueous silver nitrate was added and the silver bromide precipitate formed was filtered, washed with deionised water, dried and weighed.

The mass of dry silver bromide formed was 6.294 g.

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Analysis of results

Method 1: Titration

(a) Describe how the student should carry out **one** titration to determine accurately the volume of hydrochloric acid needed for complete reaction.

Assume that the hydrochloric acid is already in the burette. [4]

Pipette 25.0 cm^3 of solution X into a conical flask on a white tile and add 3 to 5 drops of indicator (e.g. phenolphthalein).

Record the initial burette reading (to 2 decimal places).

Add the acid while swirling the flask, washing the sides of the flask with deionised water.

When the indicator starts to change colour, add the acid drop by drop until the first permanent colour change.

Record the final burette reading; titre = final – initial.

(b) Complete the results table opposite. Use the concordant results to calculate the mean titre. [2]

concordant titres: 2, 3 and 4 (within 0.20 cm^3)

mean = (20.35 + 20.15 + 20.25) ÷ 3 = 20.25

Mean titre = 20.25 cm^3

(c) Suggest a possible reason why the reading for titration **1** was too high. [1]

The end point was overshot because titration 1 was a rough (trial) titration, so too much acid was added.

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(d) Calculate the percentage purity of the 1-bromobutane (M_r 137) based on the results of the titration. [4]

$n(NaOH)$ added $= 2.80 \times 100 \div 1000 = 0.280$ mol

$n(HCl) = 0.980 \times 20.25 \div 1000 = 0.01985$ mol $= n(NaOH)$ left in 25.0 cm^3

excess $n(NaOH)$ in 250 $cm^3 = 0.01985 \times 10 = 0.1985$ mol

$n(NaOH)$ reacted $= 0.280 - 0.1985 = 0.0815$ mol

$n(C_4H_9Br) = n(NaOH)$ reacted $= 0.0815$ mol

mass of pure 1-bromobutane $= 0.0815 \times 137 = 11.17$ g

% purity $= (11.17 \div 11.624) \times 100 = 96.1$ %

Percentage purity = 96.1 %

Method 2: Gravimetric analysis

(e) Describe how the student could have checked that all the bromide ions had been precipitated as silver bromide. [2]

Take a sample of the filtrate and add more aqueous silver nitrate. If no further precipitate forms (the solution stays clear, not cloudy), all the bromide has been precipitated.

(f) Calculate the percentage purity of the 1-bromobutane (M_r 137) based on the mass of dry silver bromide formed. [3]

$n(AgBr) = 6.294 \div 187.8 = 0.0335$ mol in 100 cm^3

1 mol $AgBr \equiv 1$ mol 1-bromobutane

$n(C_4H_9Br)$ in 250 $cm^3 = 0.0335 \times 2.5 = 0.0837$ mol

mass of pure 1-bromobutane $= 0.0837 \times 137 = 11.47$ g

% purity $= (11.47 \div 11.624) \times 100 = 98.7$ %

Percentage purity = 98.7 %

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Evaluation of results

(g) Another student repeated the gravimetric analysis.

This student's percentage purity value was **slightly higher** than the value calculated in part (f).

When asked to consider why his value was higher, the student suggested the two reasons given below.

In both cases circle to show whether you agree or disagree that this could account for the higher percentage purity value.

Give your reasoning. [3]

'I did not dry the silver bromide sufficiently before weighing.'

(Agree) / Disagree

Agree: the silver bromide still contains residual water, so the mass recorded is greater than the actual mass of AgBr, giving a higher purity.

'I did not add sufficient acid to solution **X** before adding the silver nitrate solution.'

(Agree) / Disagree

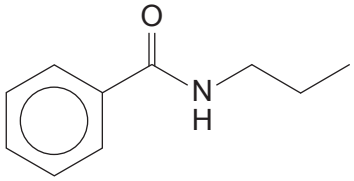
Agree: unreacted hydroxide ions would also react with silver ions to give a precipitate of silver hydroxide, so the mass recorded is greater than the mass of silver bromide.

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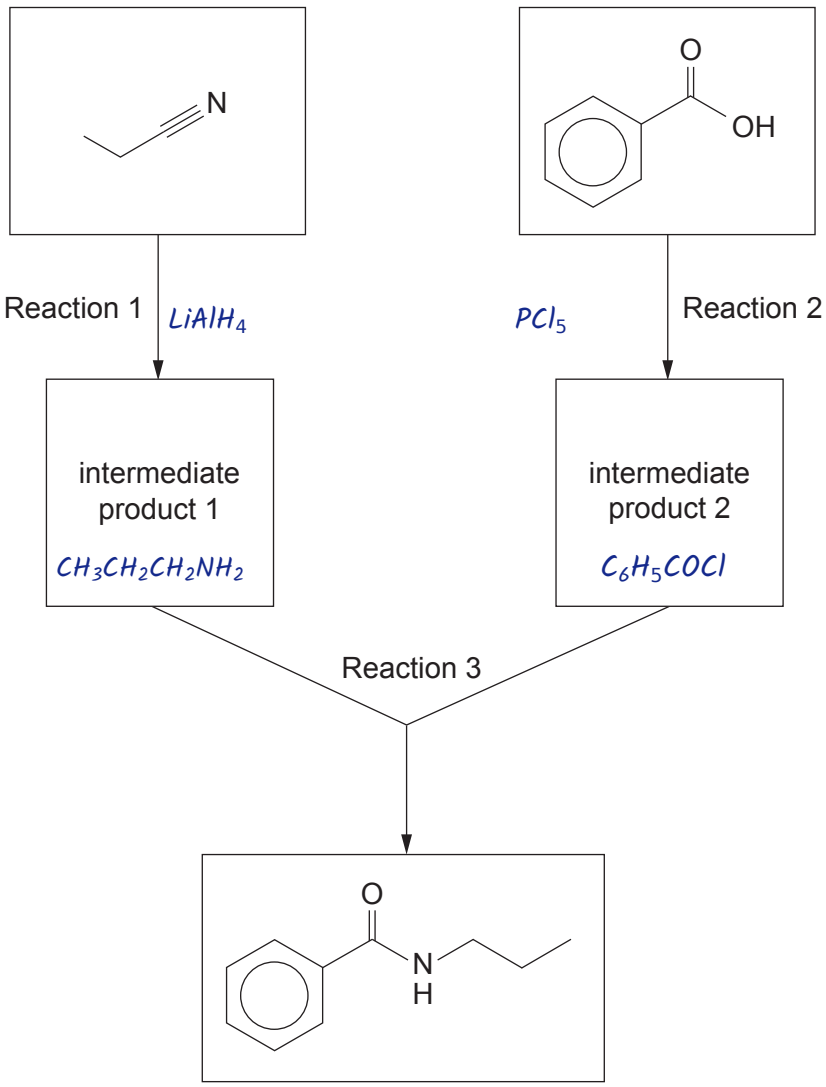
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3. N-propylbenzamide ($C_{10}H_{13}NO$) is a solid that is largely insoluble in cold water but is readily soluble in hot water.



(a) Summarise the steps in the reaction scheme for the preparation of N-propylbenzamide from propanenitrile and benzenecarboxylic acid.

No other organic compounds are available but you may use any inorganic reagents that are necessary.



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In your answer, you should give

- the reagents and reaction conditions needed to make the intermediate products
- the structures of the intermediate products
- equations for all three reactions [6 QER]

Reaction 1: reduce propanenitrile using $LiAlH_4$ in dry ethoxyethane (or H_2 with a nickel catalyst). Intermediate product 1 is propylamine, $CH_3CH_2CH_2NH_2$.

$CH_3CH_2CN + 4[H] \rightarrow CH_3CH_2CH_2NH_2$ or $CH_3CH_2CN + 2H_2 \rightarrow CH_3CH_2CH_2NH_2$

Reaction 2: react benzenecarboxylic acid with PCl_5 under dry conditions (or $SOCl_2$). Intermediate product 2 is benzoyl chloride, C_6H_5COCl.

$C_6H_5COOH + PCl_5 \rightarrow C_6H_5COCl + POCl_3 + HCl$ or $C_6H_5COOH + SOCl_2 \rightarrow C_6H_5COCl + SO_2 + HCl$

Reaction 3: mix propylamine with benzoyl chloride at room temperature. The lone pair on the nitrogen attacks the C=O carbon (nucleophilic addition-elimination) and HCl is lost, forming the amide.

$C_6H_5COCl + CH_3CH_2CH_2NH_2 \rightarrow C_6H_5CONHCH_2CH_2CH_3 + HCl$

With excess amine the HCl is neutralised: $C_6H_5COCl + 2CH_3CH_2CH_2NH_2 \rightarrow C_6H_5CONHCH_2CH_2CH_3 + CH_3CH_2CH_2NH_3Cl$

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(b) Outline how impure N-propylbenzamide could be purified. [3]

Dissolve the impure solid in the minimum volume of hot water.

Filter the hot solution to remove any insoluble impurities.

Allow the filtrate to cool so that N-propylbenzamide crystallises, then filter off the crystals (under reduced pressure), wash with a little cold water and dry.

(c) In a typical reaction, 172.6 g of benzenecarboxylic acid is converted to N-propylbenzamide.

If the percentage yield for the conversion is 52.6%, calculate the mass of N-propylbenzamide formed. [2]

n(benzenecarboxylic acid) = 172.6 ÷ 122 = 1.41 mol

n(N-propylbenzamide) = 1.41 × 52.6 ÷ 100 = 0.742 mol

mass = 0.742 × 163 = 120.9 g

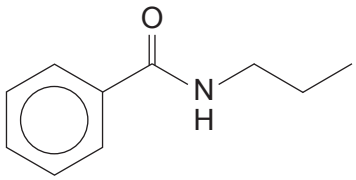
Mass of N-propylbenzamide = 120.9 g

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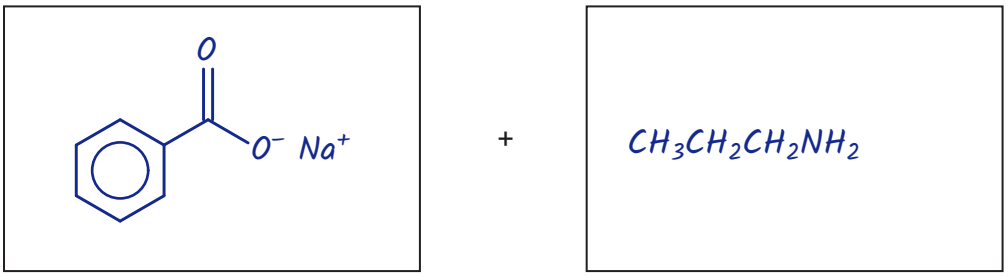
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(d) Complete the equation for the alkaline hydrolysis of N-propylbenzamide. [1]



+ NaOH

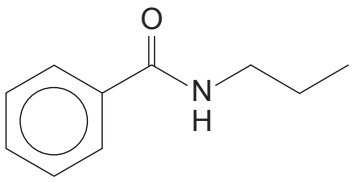


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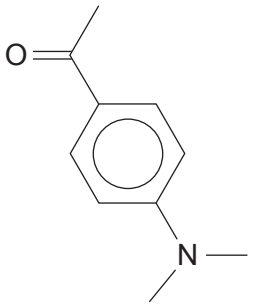
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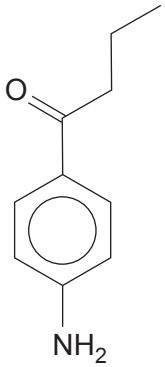
(e) $C_{10}H_{13}NO$ has a number of different isomers. Four of them are shown below.



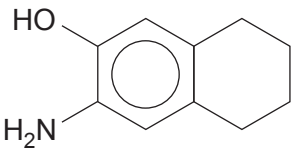
N-propylbenzamide



compound **K**



compound **L**



compound **M**

(i) State a chemical test that will give a positive result for compounds **K** and **L** but not for N-propylbenzamide or compound **M**. [1]

Reagent(s) *2,4-dinitrophenylhydrazine (2,4-DNPH)*

Observation *orange-red precipitate forms*

(ii) State a chemical test that will give a positive result for compounds **L** and **M** but not for N-propylbenzamide or compound **K**. [1]

Reagent(s) *sodium nitrate(III) and hydrochloric acid (nitric(III) acid)*

Observation *bubbles of gas (N_2) given off*

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(iii) State a chemical test that will give a positive result for compound **M** but not for N-propylbenzamide or compounds **K** or **L**. [1]

Reagent(s) *aqueous iron(III) chloride*

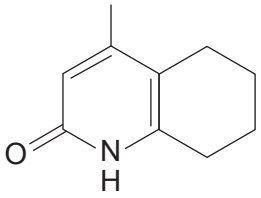
Observation *purple coloured solution forms*

(iv) State a chemical test that will give a positive result for compound **K** but not for N-propylbenzamide or compounds **M** or **L**. [1]

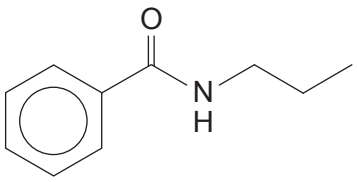
Reagent(s) *iodine and aqueous sodium hydroxide, warm*

Observation *pale yellow solid (precipitate of CHI_3) forms*

(f) Compound **N** is another isomer of formula $C_{10}H_{13}NO$.



compound **N**



N-propylbenzamide

Describe the similarities and differences in the infrared absorption spectra of compound **N** and N-propylbenzamide. Give the relevant bonds and their wavenumbers.

Refer to **both** compounds when considering the similarities and differences. [3]

Similar: both have a C=O peak at 1650 to 1750 cm^{-1} and an N–H peak at 3300 to 3500 cm^{-1}.

Different: only compound N has a C=C (alkene) peak at 1620 to 1670 cm^{-1}; N-propylbenzamide does not.

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4. Azurite is a deep blue copper-containing mineral. For many centuries, finely ground rock containing azurite has been used as a pigment to prepare a range of blue-coloured paints.

A student was told that azurite is a mixture of copper(II) carbonate and copper(II) hydroxide, with the formula $Cu_{\mathbf{a}}(CO_3)_{\mathbf{b}}(OH)_{\mathbf{c}}$.

The student performed a series of experiments to determine the exact formula of azurite.

	Experiment	Result
1	0.080 mol of azurite was added to an excess of nitric acid. The solution was made up to 500 cm^3 and labelled as solution **W**.	A volume of 3.87 dm^3 of gas was released at 21 °C and 1 atm pressure.
2	An excess of potassium iodide was added to 25.0 cm^3 of solution **W**.	The iodine formed required 17.60 cm^3 of sodium thiosulfate of concentration 0.682 mol dm^{-3} for complete reaction.

(a) Use the data from experiment 1 to calculate the value of **b**, the number of carbonate ions in each formula unit. [3]

$p = 1\ atm = 1.01 \times 10^5\ Pa,\ \ V = 3.87\ dm^3 = 3.87 \times 10^{-3}\ m^3$

$T = 21 + 273 = 294\ K$

$n(CO_2) = pV \div RT = (1.01 \times 10^5 \times 3.87 \times 10^{-3}) \div (8.31 \times 294)$

$n(CO_2) = 0.160\ mol$

$azurite : CO_2 = 0.080 : 0.160 = 1 : 2$

each CO_3^{2-} releases one CO_2, so $b = 2$

b = 2

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(b) In experiment 2, aqueous copper(II) ions react with iodide ions.

(i) Give the ionic equation for the reaction of copper(II) ions with iodide ions. [1]

$2Cu^{2+}(aq) + 4I^{-}(aq) \rightarrow 2CuI(s) + I_2(aq)$

(ii) Show that the value of **a**, the number of copper(II) ions in each formula unit, is 3. [3]

$n(S_2O_3^{2-}) = 0.682 \times 17.60 \div 1000 = 0.0120$ mol

$2Cu^{2+} \equiv I_2 \equiv 2S_2O_3^{2-}$, so $n(Cu^{2+})$ in 25.0 cm^3 = 0.0120 mol

$n(Cu^{2+})$ in 500 cm^3 = $0.0120 \times 20 = 0.240$ mol

azurite : Cu^{2+} = 0.080 : 0.240 = 1 : 3

so a = 3

(c) 55.3% of the mass of each formula unit is due to copper ions.

Use this information and the value of **a** given in part (b)(ii) to calculate the relative formula mass (M_r) of azurite. [1]

$3 \times A_r(Cu) = 3 \times 63.5 = 190.5$, which is 55.3 % of M_r

$M_r = (190.5 \div 55.3) \times 100 = 344.5$

M_r = 344.5

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(d) Use **all** the information to find the formula of azurite. [3]

mass of $(OH)_c$ = 344.5 − [(3 × 63.5) + (2 × 60.0)]

= 344.5 − 310.5 = 34.0

$M_r(OH)$ = 17.0, so c = 34.0 ÷ 17.0 = 2

check charges: 3(+2) = 2(−2) + 2(−1)

Formula $Cu_3(CO_3)_2(OH)_2$

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