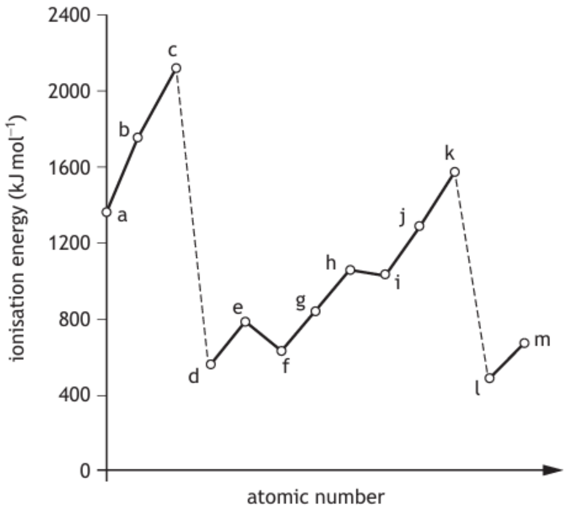
Periodicity

1. State what is meant by the term **first ionisation energy**.



2. Explain why there is an increase in first ionisation energy from elements **d** to **k** in the diagram.

3. State an element from **a** to **m** in the diagram that represents an element from group 7. 1

4. State what is meant by the term electronegativity.

5. Explain why the first ionisation energy of the group 7 elements decreases going down the group.

6. State the trend in electronegativity as you go across period 2 from lithium to fluorine. 1

7. No electronegativity values are shown for the elements with atomic numbers 2, 10 and 18.

   Suggest why no values are provided for these elements. 1

8. Explain why the electronegativity of the elements decreases as you go down the group. 1

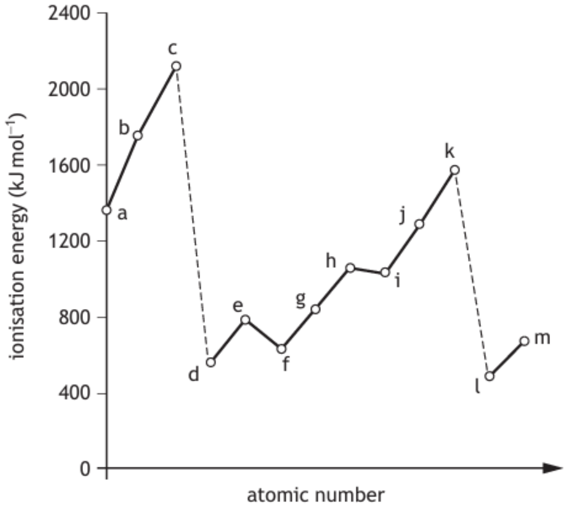
9. Explain why the first ionisation energy of the group 7 elements decreases going down the group.

10. Explain why the covalent radius of sulfur is smaller than that of phosphorus. 1

Periodicity

1. State what is meant by the term **first ionisation energy**.

the energy required to remove one mole of electrons from one mole of gaseous atoms.



2. Explain why there is an increase in first ionisation energy from elements **d** to **k** in the diagram.

Increasing nuclear charge/number of protons

3. State an element from **a** to **m** in the diagram that represents an element from group 7. 1

B or J

4. State what is meant by the term electronegativity.

attraction an atom has for the electrons in a bond

5. Explain why the first ionisation energy of the group 7 elements decreases going down the group.

Increased shielding

6. State the trend in electronegativity as you go across period 2 from lithium to fluorine. 1

increases

7. No electronegativity values are shown for the elements with atomic numbers 2, 10 and 18.

Suggest why no values are provided for these elements. 1

noble gases are unreactive/don't form covalent bonds

8. Explain why the electronegativity of the elements decreases as you go down the group. 1

Screening increases so less attraction

9. Explain why the first ionisation energy of the group 7 elements decreases going down the group.

Increased shielding

10. Explain why the covalent radius of sulfur is smaller than that of phosphorus. 1

Increased nuclear charge

Bonding

1. State the term used to describe the type of **covalent** bond in hydrogen fluoride. 1

2. Carbon can exist in multiple forms. Two of these are fullerenes and diamond.

(i) Name another form of carbon.

Form of carbon	Strongest attraction broken
diamond	
fullerene	

3. State the term used to describe the structure of solid ionic compounds like lithium nitride. 1

4. Explain how London dispersion forces arise.

5.

Substance	*Melting point (°C)*	*Strongest type of attraction broken when substance melts*
sulfur	113	
silicon dioxide	1610	

6. Explain what is meant by a pure covalent bond.

7. Titanium chloride is a liquid at room temperature.

Suggest the type of **bonding and structure** present in titanium chloride. 1

8. Name the type of intermolecular force that is responsible for the anomalous boiling point of ammonia, NH_3.

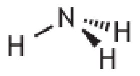
9. Suggest why the reaction is carried out in an argon atmosphere. 1

10. Explain why diatomic elements form non-polar molecules.

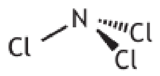
11. Hydrogen fluoride, HF, has the highest boiling point of the hydrogen halides.

State the name of the strongest type of intermolecular force found between hydrogen fluoride molecules and explain how this type of intermolecular force arises.

12. Explain the difference in polarities of ammonia and trichloramine molecules.



ammonia



trichloramine

2

Bonding

1

State the term used to describe the type of **covalent** bond in hydrogen fluoride.

Polar (covalent)

Carbon can exist in multiple forms. Two of these are fullerenes and diamond.

(i) Name another form of carbon.

Graphite

Form of carbon	Strongest attraction broken
diamond	Covalent bond
fullerene	LDF

State the term used to describe the structure of solid ionic compounds like lithium nitride. 1

lattice

Explain how London dispersion forces arise.

Forces of attraction between temporary dipoles & induced dipoles. (1 mark)

Temporary dipole caused by uneven distribution of electrons (1 mark)

Substance	*Melting point (°C)*	*Strongest type of attraction broken when substance melts*
sulfur	113	LDF
silicon dioxide	1610	Covalent bond

Explain what is meant by a pure covalent bond.

Atoms have same electronegativity.

Titanium chloride is a liquid at room temperature.

Suggest the type of **bonding and structure** present in titanium chloride. 1

Covalent molecular

Name the type of intermolecular force that is responsible for the anomalous boiling point of ammonia, NH_3.

hydrogen

Suggest why the reaction is carried out in an argon atmosphere. 1

inert/unreactive

Explain why diatomic elements form non-polar molecules.

same electronegativity

Hydrogen fluoride, HF, has the highest boiling point of the hydrogen halides.

State the name of the strongest type of intermolecular force found between hydrogen fluoride molecules and explain how this type of intermolecular force arises.

H bond between molecules that have hydrogen bonded to N, O or F

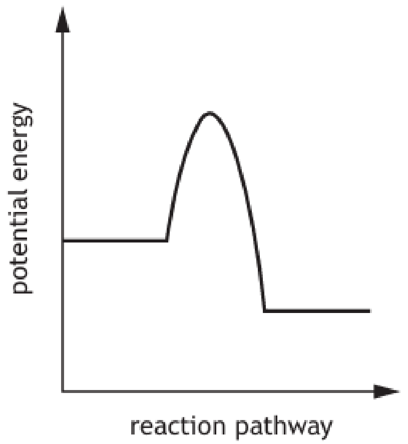
Explain the difference in polarities of ammonia and trichloramine molecules.

Ammonia is polar and trichloramine is non-polar. Ammonia has a bigger electronegativity difference between N and H atoms compared to N and Cl in trichloroamine.

Rates

1. State the term used to describe the minimum kinetic energy required by particles before a reaction can occur successfully.

2.



Add a dotted line to the diagram to show the change in potential energy for the formation of an ester carried out **without** a catalyst. **1**

3. State the effect of adding a catalyst on the enthalpy change for this reaction.

4. Circle the correct statement in each column of the table to show the effect of using a catalyst in the reaction.

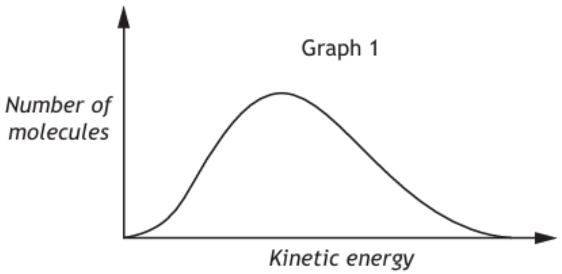
Effect of catalyst on enthalpy change	Effect of catalyst on activation energy
increase stay the same decrease	increase stay the same decrease

5. Explain, in terms of collision theory, why fine powders ensure fast reactions in the air bag. **2**

6.

Feature of reaction	Effect of catalyst
Rate of forward reaction	increase/decrease/no effect
Rate of reverse reaction	increase/decrease/no effect
Position of equilibrium	moves to right/moves to left/no effect

7. Graph 1 shows the distribution of kinetic energies of molecules in a gas at 100 °C.



Add a second curve to graph 1 to show the distribution of kinetic energies at 50 °C. 1

8. Collision theory states that for particles to react they must first collide with each other.

State **two** conditions necessary for the collisions to result in the formation of products. **2**

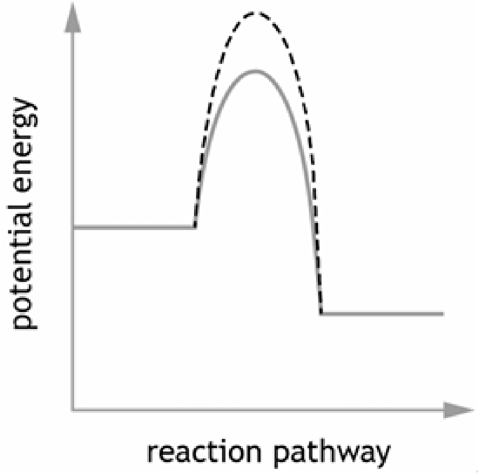
9. Explain why the aluminium foil needs to be heated at the start of the preparation, despite the reaction being highly exothermic. **1**

Rates

1. State the term used to describe the minimum kinetic energy required by particles before a reaction can occur successfully.

Activation energy

2.



Add a dotted line to the diagram to show the change in potential energy for the formation of an ester carried out **without** a catalyst. 1

3. State the effect of adding a catalyst on the enthalpy change for this reaction.

None

4. Circle the correct statement in each column of the table to show the effect of using a catalyst in the reaction.

Increase stay the same decrease	increase stay the same decrease

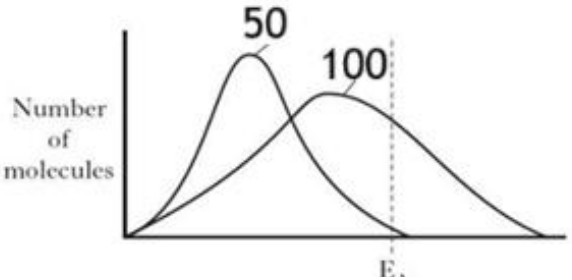
5. Explain, in terms of collision theory, why fine powders ensure fast reactions in the air bag. 2

Powders have larger surface area (1)
More successful collisions (1)

6.

Feature of reaction	Effect of catalyst
Rate of forward reaction	Increase
Rate of reverse reaction	Increase
Position of equilibrium	No effect

7.



8. Collision theory states that for particles to react they must first collide with each other.

State **two** conditions necessary for the collisions to result in the formation of products. 2

Particles must have energy equal to or greater than the activation energy
Collision must occur with correct/geometry/ orientation

Explain why the aluminium foil needs to be heated at the start of the preparation, despite the reaction being highly exothermic. 1

To provide initial activation energy to form the activated complex

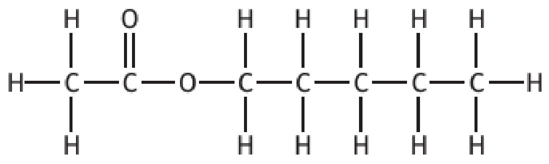
Esters

1. Name the functional group in propyl octanoate.

2. State the systematic name for this ester.

$CH_3(CH_2)_6COOCH_3$

3. The structure of an ester used to produce a pear flavour in some sweets is

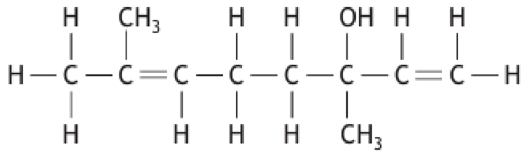


4. Name this ester. 1

5. Name the type of reaction used to form esters. 1

condensation/esterification

6a) State the systematic name for linalool.

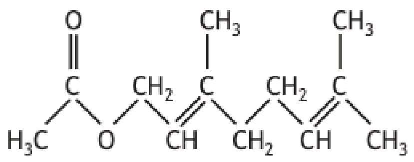


b) Explain why linalool can be classified as a tertiary alcohol.

hydroxyl attached to a C that has no H atoms attached

7. Geranyl acetate can undergo hydrolysis to produce an alcohol and another product.

Name the other product. 1



geranyl acetate

8. Draw a labelled diagram to show apparatus suitable for preparing an ester. 2

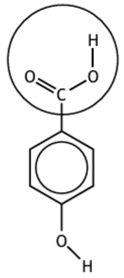
9. 4-hydroxybenzoic acid can react with alcohols to form compounds known as parabens.

Name the type of reaction taking place when parabens are formed. 1

10. A compound added to cheese as a mould inhibitor has the formula $Ca^{2+}(CH_3CH_2COO^-)_2$.

Name this compound.

11. Name the functional group circled in the structure of 4-hydroxybenzoic acid. 1



4-hydroxybenzoic acid

Esters

1. Name the functional group in propyl octanoate.

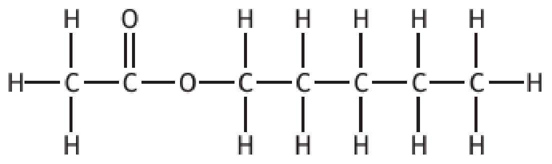
Ester link

2. State the systematic name for this ester.

$CH_3(CH_2)_6COOCH_3$

Methyl octanoate

3. The structure of an ester used to produce a pear flavour in some sweets is



Name this ester. 1

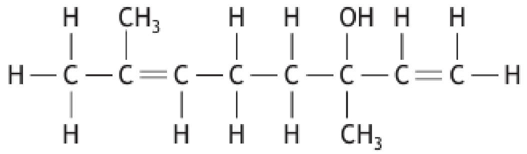
pentyl ethanoate

4. Name the type of reaction used to form esters. 1

condensation/esterification

5a) State the systematic name for linalool.

3,7-dimethylocta-1,6-dien-3-ol

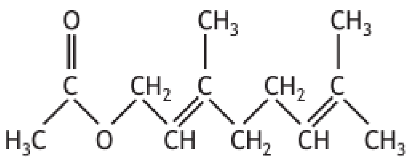


b) Explain why linalool can be classified as a tertiary alcohol.

7. Geranyl acetate can undergo hydrolysis to produce an alcohol and another product.

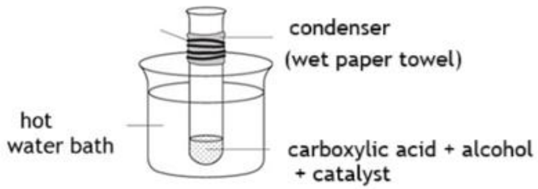
Name the other product. 1

Ethanoic acid



geranyl acetate

8. Draw a labelled diagram to show apparatus suitable for preparing an ester. 2



9. 4-hydroxybenzoic acid can react with alcohols to form compounds known as parabens.

Name the type of reaction taking place when parabens are formed. 1

Condensation/esterification

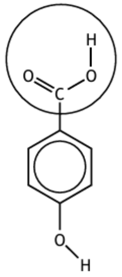
10. A compound added to cheese as a mould inhibitor has the formula $Ca^{2+}(CH_3CH_2COO^-)_2$.

Name this compound.

Calcium propanoate

11. Name the functional group circled in the structure of 4-hydroxybenzoic acid. 1

carboxyl



4-hydroxybenzoic acid

Fats & Soaps

1. Name the functional group present in all fats and oils.

2. Draw a structural formula for glycerol.

3. Name the type of reaction used to form fat molecules from fatty acids and glycerol.

4. State the systematic name for glycerol.

5. State a reason why fats and oils form part of a balanced diet.

6. Explain why glycerol is able to form fats and oils.

7. Soaps are salts of fatty acids. One common fatty acid used in soaps is myristic acid, $C_{13}H_{27}COOH$.

   Write a formula for the sodium salt of myristic acid.

8. Explain why soapless detergents are used in areas of hard water instead of soaps. 1

9. State how emulsifiers are made from edible oils.

10. State the function of an emulsifier.

11. Describe the key structural features of a soapless detergent molecule.

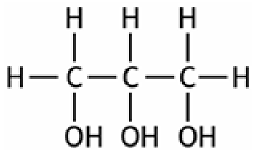
12. Name the reaction used to make soaps from fats and oils. 1

Fats & Soaps

1. Name the functional group present in all fats and oils.

ester

2. Draw a structural formula for glycerol.



3. Name the type of reaction used to form fat molecules from fatty acids and glycerol.

Condensation/esterification

4. State the systematic name for glycerol.

propane-1,2,3-triol

5. State a reason why fats and oils form part of a balanced diet.

Concentrated source of energy OR
essential for the transport of fat-soluble vitamins in the body

6. Explain why glycerol is able to form fats and oils.

Glycerol has 3 hydroxyl groups.

7. Soaps are salts of fatty acids. One common fatty acid used in soaps is myristic acid, $C_{13}H_{27}COOH$.

Write a formula for the sodium salt of myristic acid.

C13H27COONa

8 Explain why soapless detergents are used in areas of hard water instead of soaps. 1

To prevent scum forming

9 State how emulsifiers are made from edible oils.

Reacting with glycerol

10 State the function of an emulsifier.

To prevent non-polar and polar liquids separating

11 Describe the key structural features of a soapless detergent molecule.

Head	**Tail**
Hydrophilic	Hydrophobic
Polar	Non-polar
Ionic	Non-polar
Water soluble	Fat soluble

12 Name the reaction used to make soaps from fats and oils. 1

alkaline hydrolysis/saponification

Protein

1. State what is meant by an essential amino acid.

2. Name the process occurring when protein fibres change shape.

3. Name the other product formed when amino acids join to form proteins such as keratin.

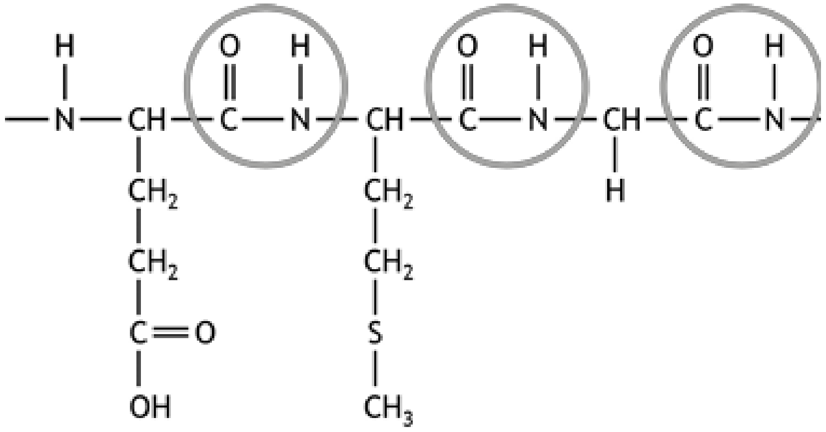
4. Leucine and valine are amino acids that must be obtained through the diet.

   State the term for this type of amino acid. 1

5. State what is meant by the term enzyme.

6. Name the type of reaction that takes place when amino acids join to form proteins.

7.



Name the family of compounds to which enzymes belong. 1

8. State the name of the digestion process where enzymes break down proteins into amino acids. 1

Protein

1. State what is meant by an essential amino acid.

An amino acid that must be obtained from the diet

2. Name the process occurring when protein fibres change shape.

denaturing

3. Name the other product formed when amino acids join to form proteins such as keratin.

water

4. Leucine and valine are amino acids that must be obtained through the diet.

State the term for this type of amino acid. 1

essential

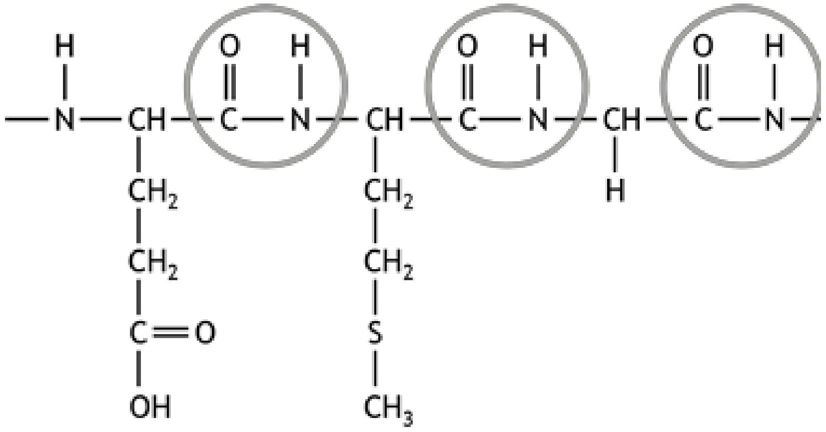
5. State what is meant by the term enzyme.

Biological catalyst

6. Name the type of reaction that takes place when amino acids join to form proteins.

Condensation

7.



Name the family of compounds to which enzymes belong. 1

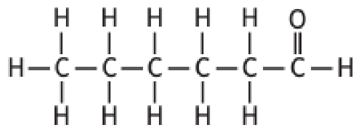
protein

8. State the name of the digestion process where enzymes break down proteins into amino acids. 1

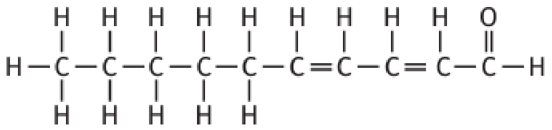
hydrolysis

Oxidation of food 1

1.



molecule A



molecule B

Describe a chemical test, and the expected result, that could be used to distinguish between these two molecules. **1**

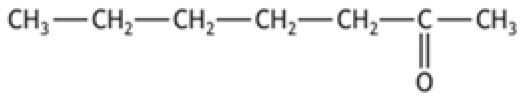
2. Fats and oils can react with oxygen from the air.

   (i) State the term used to describe the resulting unpleasant flavour.

3 Explain why antioxidants are added to food.

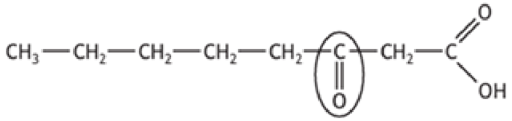
4. Name molecule **Y**.

Y



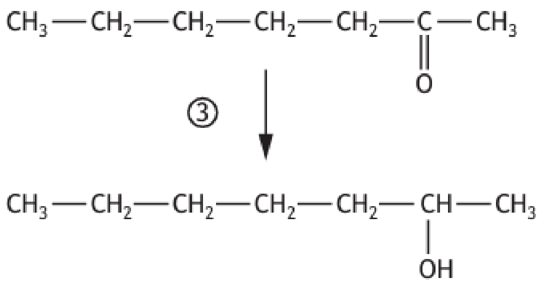
5. Identify the functional group circled in molecule **X**.

X



6. Identify the type of reaction used to convert molecule **Y** into molecule **Z**.

Y



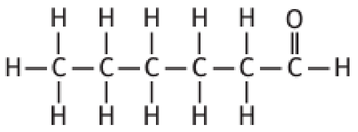
Z

7. Further oxidation of ethanal can produce another product that spoils the flavour of cider.

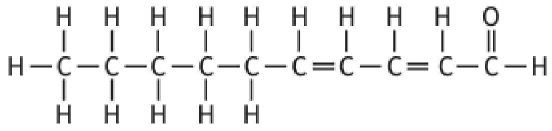
   Name this product. **1**

Oxidation of food 1

1.



molecule A



molecule B

Describe a chemical test, and the expected result, that could be used to distinguish between these two molecules. 1

Bromine solution will decolourise with molecule B but not molecule A

2. Fats and oils can react with oxygen from the air.

(i) State the term used to describe the resulting unpleasant flavour.

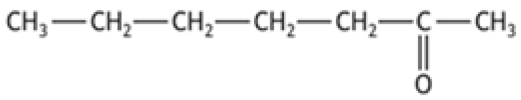
rancid

3 Explain why antioxidants are added to food.

to stop food acquiring a rancid flavour/unwanted oxidation.

4. Name molecule Y.

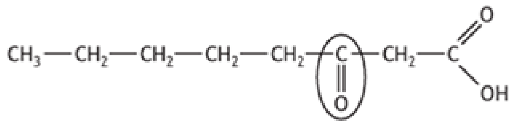
Y



heptan-2-one

5. Identify the functional group circled in molecule X.

X

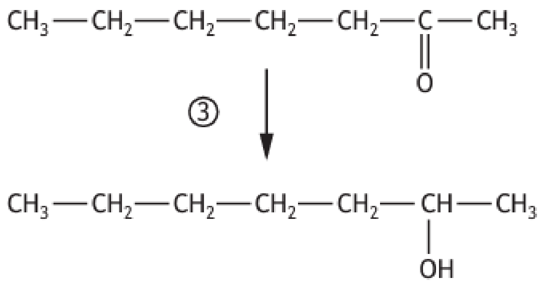


carbonyl

6. Identify the type of reaction used to convert molecule Y into molecule Z.

Y

Z



Reduction

7. Further oxidation of ethanal can produce another product that spoils the flavour of cider.

Name this product. 1

Ethanoic acid

Oxidation of food 2

1. Describe a chemical test, with the expected result for **both** compounds, that could be used to distinguish between methanol and propan-2-one. **2**

2. State the name of this alcohol.

$CH_3CH(CH_3)CH_2CH_2OH$

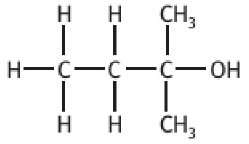
3. State the colour change that would be observed when propan-1-ol reacts with acidified potassium dichromate.

4. The equation for the reduction of another oxidising agent that could be used to oxidise propan-1-ol is shown below.

$$Ag^{+}(aq) \ + \ e^{-} \ \rightarrow \ Ag(s)$$

Name the reagent that provides this oxidising agent.

5. State why 2-methylbutan-2-ol cannot be oxidised using these oxidising agents. **1**

6. 

Name this alcohol.

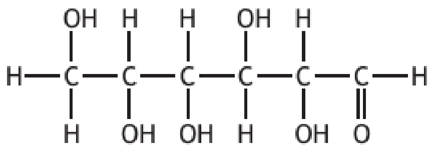
7. (i) Vanillin is an aldehyde and carvone is a ketone.

(A) State the colour change that would be observed when aldehydes react with acidified potassium dichromate. **1**

(B) Suggest a different chemical that could be used to distinguish aldehydes from ketones. **1**

8. One test for glucose involves Fehling's solution.

Circle the part of the glucose molecule that reacts with Fehling's solution. **1**



Oxidation of food 2

1. Describe a chemical test, with the expected result for **both** compounds, that could be used to distinguish between methanol and propan-2-one. **2**

Acidified dichromate changes from orange to green with methanol AND no colour change with propan-2 one OR

Using hot copper colour change from black to brown would be observed with methanol AND no colour change with propan-2-one.

2. State the name of this alcohol.

$CH_3CH(CH_3)CH_2CH_2OH$

3-methylbutan-1-ol

3. State the colour change that would be observed when propan-1-ol reacts with acidified potassium dichromate.

Orange to green

4. The equation for the reduction of another oxidising agent that could be used to oxidise propan-1-ol is shown below.

$$Ag^+(aq) + e^- \rightarrow Ag(s)$$

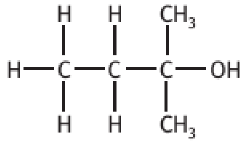
Name the reagent that provides this oxidising agent.

Tollens'

5. State why 2-methylbutan-2-ol cannot be oxidised using these oxidising agents. 1

tertiary alcohol.

6.



Name this alcohol.

2-methylbutan-2-ol

7. (i) Vanillin is an aldehyde and carvone is a ketone.

(A) State the colour change that would be observed when aldehydes react with acidified potassium dichromate. 1

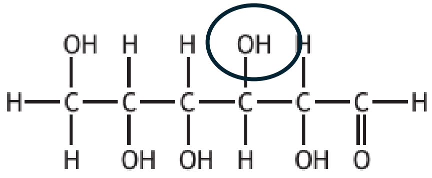
orange to green

(B) Suggest a different chemical that could be used to distinguish aldehydes from ketones. 1

Tollens' reagent OR Fehling's solution

8. One test for glucose involves Fehling's solution.

Circle the part of the glucose molecule that reacts with Fehling's solution. 1



Skin care/Fragrance

1. State what is meant by the term free radical.

2. State how free radical scavengers prevent chain reactions from occurring. 1

3. $F_2 \rightarrow 2F\bullet$

State the name given to this step.

4. Name the type of reaction that occurs when two free radicals join together. 1

5. Another step in the process is shown below.

$NH_2Cl + \bullet Cl \longrightarrow \bullet NHCl + HCl$

State the name for this type of step in a free radical reaction. 1

6. Name the component of sunlight that can cause plastics such as PET to break down. 1

7. Name the type of substance that can be added to plastics to prevent them breaking down in this way. 1

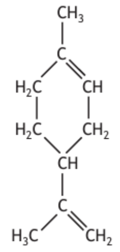
8. Describe how free radicals are formed.

8. State one property of an essential oil.

9. State the systematic name for an isoprene unit.

10. Name the type of compound formed when isoprene units join together.

11. Name the class of compounds to which unsaturated hydrocarbons such as limonene and myrcene belong.



limonene

12. Isoprene is also called 2-methyl-1,3-butadiene.

Draw a structural formula for isoprene.

13 State the term used to describe the mixture of volatile, non-water-soluble aroma compounds obtained from plants.

Skin care/Fragrance

1. State what is meant by the term free radical.

Atom with an unpaired electron

2. State how free radical scavengers prevent chain reactions from occurring. 1

Can react with free radicals forming stable molecules OR donate an electron.

3. $F_2 \rightarrow 2F\bullet$

State the name given to this step.

initiation

4. Name the type of reaction that occurs when two free radicals join together. 1

termination

5. Another step in the process is shown below.

$NH_2Cl + \bullet Cl \longrightarrow \bullet NHCl + HCl$

State the name for this type of step in a free radical reaction. 1

propagation

6. Name the component of sunlight that can cause plastics such as PET to break down. 1

UV

7. Name the type of substance that can be added to plastics to prevent them breaking down in this way. 1

Anti oxidant/free radical scavenger

8. Describe how free radicals are formed.

Bond breaking with UV light

1. State one property of an essential oil.

Volatile/non-water soluble/aroma

2. State the systematic name for an isoprene unit.

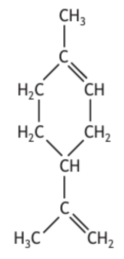
2-methylbuta-1,3-diene

3. Name the type of compound formed when isoprene units join together.

terpene

4. Name the class of compounds to which unsaturated hydrocarbons such as limonene and myrcene belong.

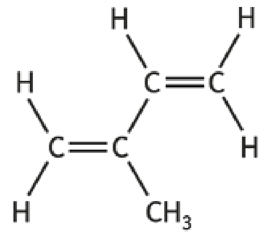
terpene



limonene

5. Isoprene is also called 2-methyl-1,3-butadiene.

Draw a structural formula for isoprene.



6. State the term used to describe the mixture of volatile, non-water-soluble aroma compounds obtained from plants.

Essential Oil

Titration

1. State what is meant by a standard solution.

2. An indicator was added to the seawater in a conical flask.

   State why an indicator is used.

3. Describe how a pipette should be prepared and used to accurately measure the sample of seawater. 2

4. The table shows the results obtained.

Sample	Volume of silver nitrate used (cm^3)
1	11.90
2	11.60
3	11.50

A) Explain why the average titre value is 11.55 cm^3, not 11.70 cm^3.

5. Name the piece of apparatus which should be used to transfer 10 cm^3 of stock solution to a standard flask. 1

6. Name the **two** pieces of equipment that would be required to accurately measure the volumes of hydrogen peroxide and potassium permanganate used in the titration. 1

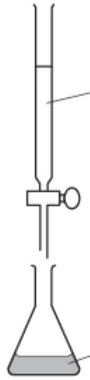
7. Copper(II) ethanoate can be made by reacting copper(II) carbonate with ethanoic acid.

   (i) Name the other products of this reaction.

8. State the term used to describe titre volumes within 0.2 cm^3 of each other. 1

9. The indicator used in this titration is phenolphthalein. Phenolphthalein is colourless in acidic and neutral solutions but is pink in alkaline conditions.

   State the colour change that would be observed at the end point in this titration. 1



10. Explain why the student should use deionised water or distilled water, rather than tap water, when preparing the stock solution. 1

Titration

1. State what is meant by a standard solution.

Solution of accurately known concentration

2. An indicator was added to the seawater in a conical flask.

State why an indicator is used.

To identify the end point.

3. Describe how a pipette should be prepared and used to accurately measure the sample of seawater. 2

Rinse with seawater
Fill above the mark and allow liquid to drop down to the mark
OR
Fill to mark, read from the bottom of the meniscus

4. The table shows the results obtained.

Sample	Volume of silver nitrate used (cm^3)
1	11.90
2	11.60
3	11.50

A) Explain why the average titre value is 11.55 cm^3, not 11.70 cm^3.

Only concordant values are used

5. Name the piece of apparatus which should be used to transfer 10 cm^3 of stock solution to a standard flask. 1

pipette

6. Name the **two** pieces of equipment that would be required to accurately measure the volumes of hydrogen peroxide and potassium permanganate used in the titration. 1

Burette and pipette

7. Copper(II) ethanoate can be made by reacting copper(II) carbonate with ethanoic acid.

(i) Name the other products of this reaction.

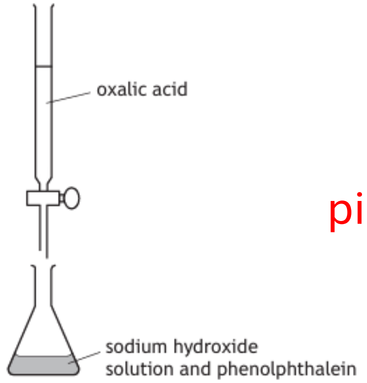
water

8. State the term used to describe titre volumes within 0.2 cm^3 of each other. 1

concordant

9. The indicator used in this titration is phenolphthalein. Phenolphthalein is colourless in acidic and neutral solutions but is pink in alkaline conditions.

State the colour change that would be observed at the end point in this titration. 1



pink to colourless

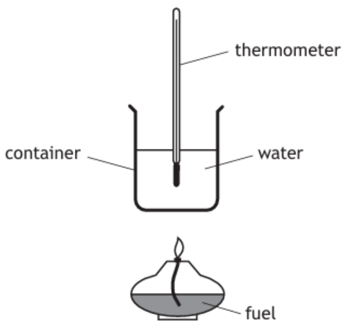
10. Explain why the student should use deionised water or distilled water, rather than tap water, when preparing the stock solution. 1

impurities / metal ions may be present in tap water

Enthalpy

1. Heat is lost to the surroundings during the experiment.

   Suggest an improvement to the apparatus that would prevent heat loss to the surroundings. **1**

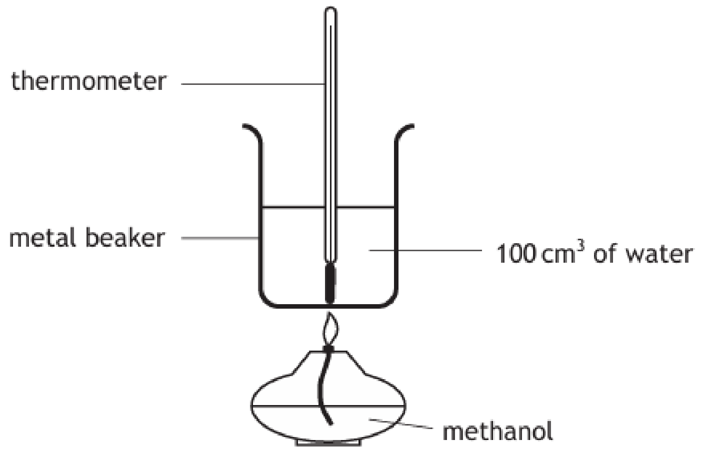


2. The student always used 100 cm^3 of water.

   State another variable that the student should have kept constant. **1**

3. Identify a feature of the bomb calorimeter and explain how this allows the accurate determination of the energy released by burning foods. **1**

4.



(A) The student carried out the first experiment as shown, but was told to repeat the experiment as the thermometer had been placed in the wrong position.

Suggest why the student's placing of the thermometer was incorrect. **1**

5. State the measurements required to calculate the mass of heptane burned in this experiment. **1**

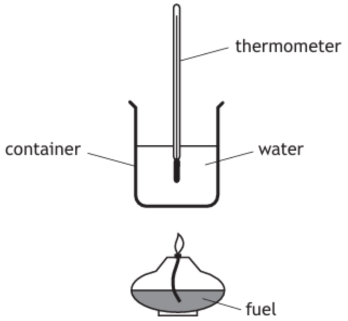
6. The theoretical value for the enthalpy of combustion of heptane is significantly higher than the experimental value.

   Suggest why the experimental value is different to the theoretical value. **1**

Enthalpy

1. Heat is lost to the surroundings during the experiment.

Suggest an improvement to the apparatus that would prevent heat loss to the surroundings. 1



Use a draught shield
Move flame closer to container
Fit a lid on the container
Insulate container

- Loss of heat/energy to the surroundings
- Incomplete combustion (of heptane/alkane)
- Loss (of heptane/alkane) by evaporation
- No lid on container
- No stirring
- Absorption of heat glass/beaker or copper can

2. The student always used 100 cm^3 of water.

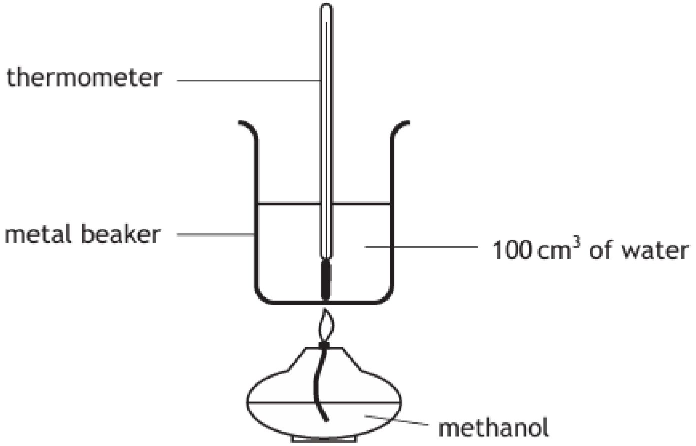
State another variable that the student should have kept constant. 1

Distance between flame and beaker
Same copper can
Same draught proofing

3. Identify a feature of the bomb calorimeter and explain how this allows the accurate determination of the energy released by burning foods. 1

Contains oxygen to ensure complete combustion
Sample is surrounded by water so all energy transferred
Sealed container preventsheat loss to the surroundings
Stirring to ensure accurate temperature

4.



(A) The student carried out the first experiment as shown, but was told to repeat the experiment as the thermometer had been placed in the wrong position.

Suggest why the student's placing of the thermometer was incorrect. 1

Thermometer touching bottom/directly above flame would result in temperature rise being greater than expected.

5. State the measurements required to calculate the mass of heptane burned in this experiment. 1

Record the mass of the burner before and after heating the water

6. The theoretical value for the enthalpy of combustion of heptane is significantly higher than the experimental value.

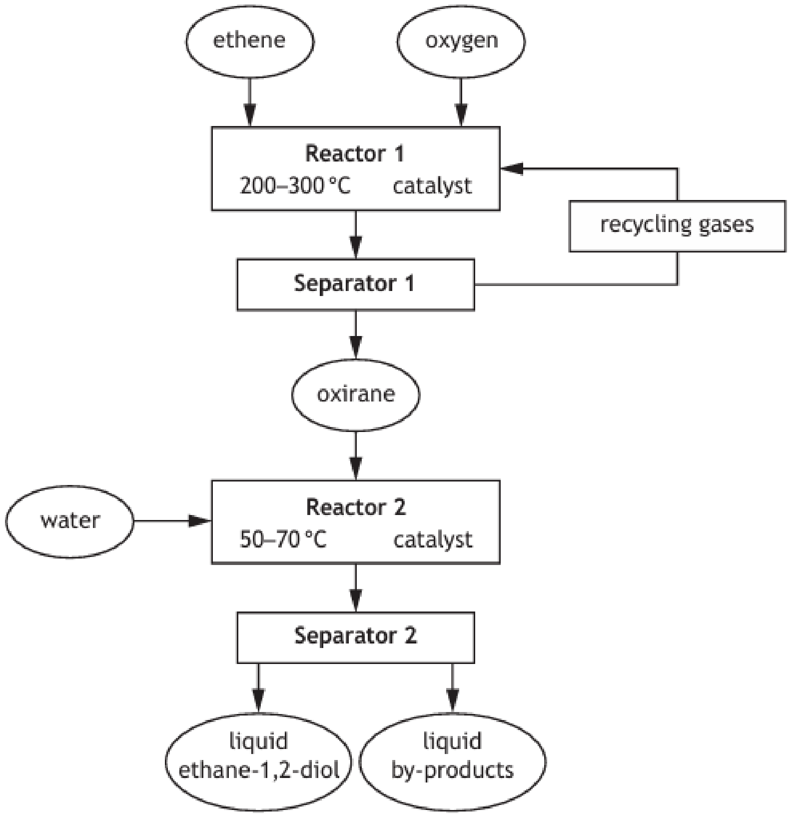
Suggest why the experimental value is different to the theoretical value. 1

Loss of heat to the surroundings
Incomplete combustion (of heptane/alkane)
Loss of heptane by evaporation
No lid on container OR No stirring

Unit 3

1. State a disadvantage of industrial processes that involve reactions that are highly exothermic. 1

2. State why it is important for chemists to predict whether reactions in an industrial process are exothermic or endothermic. 1

3. 

(i) Industrial processes are designed to maximise profit.

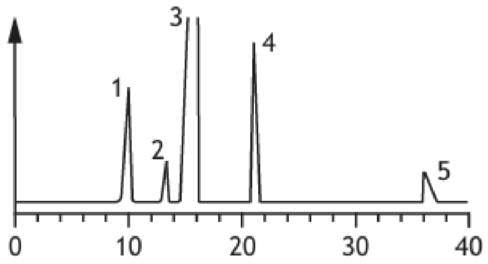
Using the flowchart, suggest two ways to maximise profit in this industrial process. 2

4. $2NO_2(g) \rightleftharpoons N_2O_4(g)$ $\Delta H = -58\ kJ\ mol^{-1}$

Complete the table to show the conditions that would maximise the yield of **nitrogen dioxide**. 1

Condition	High/Low
Temperature	
Pressure	

5. Explain the difference between bond enthalpy and mean bond enthalpy. 1

6. 

The concentration of flavour molecule 3 cannot be determined from this chromatogram.

Suggest what would need to be done to the sample to allow the concentration of flavour molecule 3 to be determined. 1

7. Apart from the polarity of the molecules, state another factor that would affect the retention time of molecules during gas chromatography. 1

Unit 3

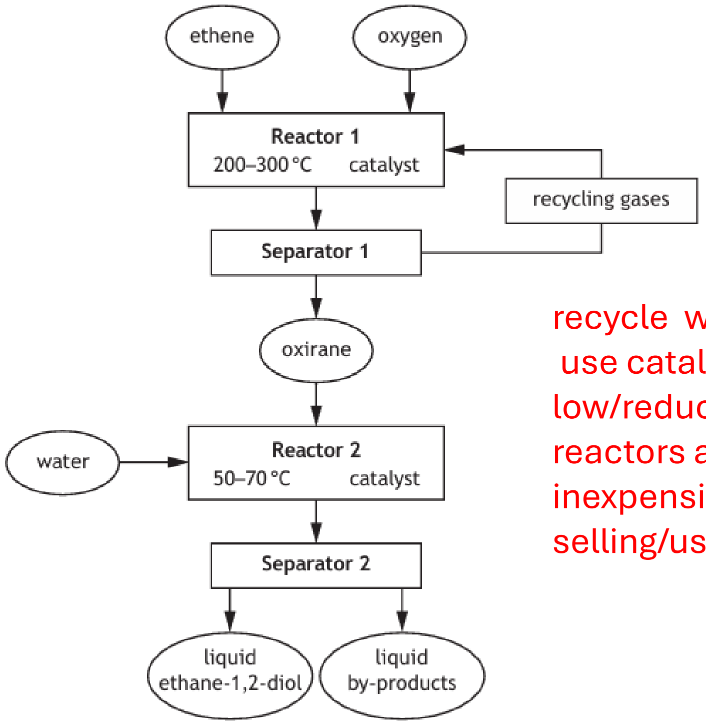
1. State a disadvantage of industrial processes that involve reactions that are highly exothermic. 1

Require heat to be removed

2. State why it is important for chemists to predict whether reactions in an industrial process are exothermic or endothermic. 1

heat will need to be removed if exothermic OR
heat will need to be supplied if endothermic

3.



recycle waste gases
use catalyst
low/reduce energy requirements
reactors are run at low temperatures
inexpensive feedstocks
selling/using by-products

(i) Industrial processes are designed to maximise profit.

Using the flowchart, suggest two ways to maximise profit in this industrial process. 2

4. $2NO_2(g) \rightleftharpoons N_2O_4(g)$ $\Delta H = -58\ kJ\ mol^{-1}$

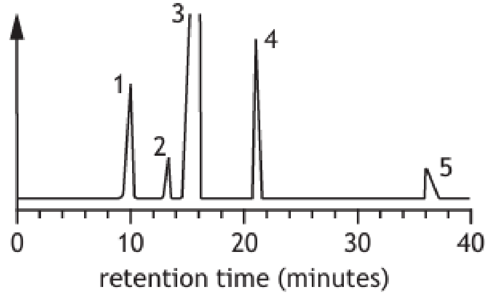
Complete the table to show the conditions that would maximise the yield of **nitrogen dioxide**. 1

Condition	High/Low
Temperature	
Pressure	

5. Explain the difference between bond enthalpy and mean bond enthalpy. 1

Mean bond enthalpy must refer to an average energy and to a number of compounds
bond enthalpy must relate to one compound.

6.



7. The concentration of flavour molecule 3 cannot be determined from this chromatogram.

Suggest what would need to be done to the sample to allow the concentration of flavour molecule 3 to be determined. 1

dilute sample

Apart from the polarity of the molecules, state another factor that would affect the retention time of molecules during gas chromatography. 1

Size of molecules

Explain why the melting point of phosphorus, P_4, is much higher than that of nitrogen, N_2. 3

In your answer you should refer to the intermolecular forces involved.

Stronger intermolecular/Van der Waals forces between phosphorus compared with nitrogen. **(1 mark)**

London dispersion forces/LDFs are the intermolecular forces present. **(1 mark)**

There are more electrons in phosphorus/P_4 compared to nitrogen/N_2. **(1 mark)**

Explain **fully**, in terms of structure and bonding, why silicon dioxide has a high melting point. 2

Silicon dioxide is a covalent network **(1 mark)**

(Strong) covalent bonds are broken **(1 mark)**

Explain **fully** why chloromethane has a lower boiling point than water.

In your answer you should refer to the intermolecular forces involved.

Chloromethane has permanent dipole to permanent dipole interactions whereas water has hydrogen bonding. **(1 mark)**

Hydrogen bonding is stronger than permanent dipole to permanent dipole interactions. **(1 mark)**

Explain **fully** why the boiling points of the group 4 hydrides increase going down the group.

In your answer you should refer to the intermolecular forces involved. 3

(Intermolecular/van der Waals) forces increase (going down the group). **(1 mark)**

LDFs are the forces (broken between the molecules). **(1 mark)**

The more electrons the stronger the LDFs. **(1 mark)**

Explain **fully** why silicon oxide has a much higher melting point than silicon hydride. 3

In SiO_2 covalent bonds are broken. **(1 mark)**

In SiH_4 Van der Waals/LDFs/intermolecular forces are broken. **(1 mark)**

Covalent bonds need more energy to break than van der Waals/LDFs/ intermolecular forces.

OR

Covalent bonds are stronger than van der Waals/LDFs/intermolecular forces. **(1 mark)**

Explain **fully** why the boiling point increases from hydrogen chloride to hydrogen iodide. 2

Correctly identify that the London dispersion forces become stronger/increase (in moving from HCl to HI). **(1 mark)**

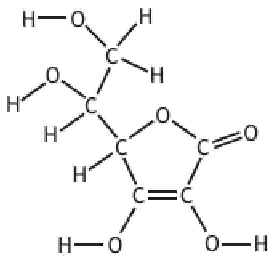
The number of electrons in the molecules increases (from HCl to HI). **(1 mark)**

Explain fully why the London dispersion forces in sulfur are stronger than those in oxygen.

1 mark
Sulfur/S has more electrons than oxygen/O

1 mark
These forces are stronger due to sulfur structure being S_8 whereas oxygen is O_2

Explain **fully** why vitamin C is soluble in water.



Vitamin C molecule is polar due to its hydroxyl groups.

OR

Vitamin C can form hydrogen bonds due to its hydroxyl groups. **(1 mark)**

An explanation which links solubility of vitamin C to the polarity of water/hydrogen bonding of water. **(1 mark)**

Explain fully, in terms of the structures of sulfur and phosphorus molecules and the intermolecular forces between molecules of each element, why the melting point of sulfur is much higher than that of phosphorus. 3

1 mark
Correctly identify that the forces are stronger between sulfur (molecules) than between the phosphorus molecules

1 mark
Correctly identifying that there are London dispersion forces between the molecules of both these elements

1 mark
These forces are stronger due to sulfur structure being S_8 whereas phosphorus is P_4

Explain **fully** the large increase between the first and second ionisation energies of sodium. **2**

Second ionisation energy involves removal of an electron **from an electron shell** that is full(whole) (1 mark)

The second electron is more strongly pulled towards the nucleus.

OR

The second electron is less screened (1 mark)

Explain **fully** why electronegativity decreases going down a group.

(More shells so) increased screening/more screening. **(1 mark)**

(Covalent radius increases/atom size increases/more shells so) attraction of the nucleus/protons for the (outer/shared) electron(s) decreases. **(1 mark)**

Explain **fully** why fats have higher melting points than oils. **3**

In your answer you should refer to the structure of fats and oils.

Fats are more saturated (with more regular shape). **(1 mark)**

This means they can pack together more closely/more compact structure. **(1 mark)**

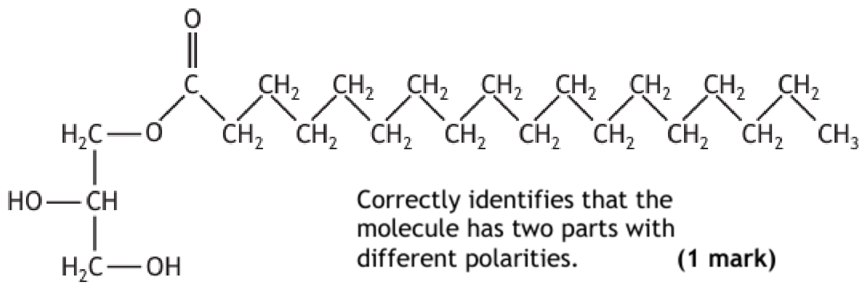
Stronger LDF/forces of attraction between the molecules. **(1 mark)**

Explain **fully** how emulsifiers prevent non-polar and polar liquids from separating into layers. **2**

Correctly identifying that the emulsifier has two parts with different polarities or two parts that are hydrophobic/hydrophilic. **(1 mark)**

Hydrophobic part/hydrocarbon chain/fatty acid chain/non-polar part dissolves in non-polar liquids whilst the hydrophilic part/hydroxyl groups/polar part dissolve in polar liquids. **(1 mark)**

Explain **fully** the reasons this molecule can act as an emulsifier.



Correctly identifies that the molecule has two parts with different polarities. **(1 mark)**

Correctly identifies that the polar part/hydroxyl groups dissolve in water/polar liquids/are hydrophillic whilst the non-polar part/hydrocarbon chain dissolve in biodiesel/non-polar liquids/are hydrophobic **(1 mark)**

3-Methylbutanal is found in olive oil. **2**

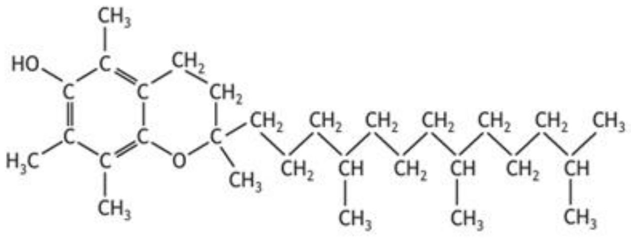
Explain **fully** what can happen to 3-methylbutanal that will cause the olive oil to develop an unpleasant taste.

Will react with oxygen/undergo oxidation. **(1)**

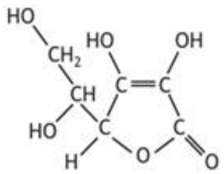
Forming a **carboxylic** acid (which has unpleasant taste). **(1)**

Antioxidants are used as preservatives in oils and fatty foods.

Explain **fully** why vitamin E is more suitable than vitamin C as an antioxidant in oils and fatty foods. 2



vitamin E



vitamin C

Vitamin E is less polar (than vitamin C)

(1 mark)

An explanation that links solubility of vitamin E to the polarity of fats and oils

(1 mark)

As sweet potatoes are cooked, the ability of catalase to break down hydrogen peroxide decreases.

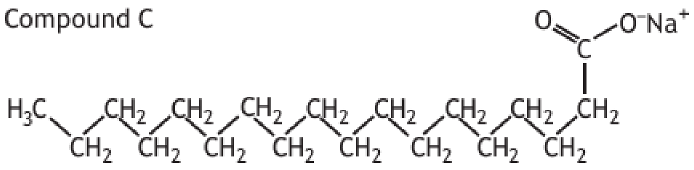
Explain **fully** what happens to the enzyme structure to cause this reduction in activity. 2

Enzyme becomes denatured/ enzyme changes shape **(1 mark)**

Intermolecular/hydrogen bonds are broken **(1 mark)**

Soap molecules allow oil to mix with water.

Compound C



Explain fully the cleaning action of compound C.

You may wish to use diagrams to illustrate your answers.

(Compound C) has an ionic/hydrophilic part **and** a non polar/hydrophobic part (or alternative wording/diagram showing knowledge of these parts of the molecule) **(1)**

Correctly identifies the part of the molecule/head/COO^- dissolves in water/ is hydrophilic and the part of the molecule/tail/hydrocarbon chain dissolves in oil/hydrophobic. **(1)**

Agitation separates oil from the surface/cause small oil droplets to form

The equation to produce ammonia is shown.

$N_2(g) \; + \; 3H_2(g) \; \rightleftharpoons \; 2NH_3(g) \qquad \Delta H = -92 \text{ kJ mol}^{-1}$

Explain fully the effect of decreasing the reaction temperature on the yield of ammonia. **2**

Decreasing temperature favours the exothermic reaction/increasing temperature favours endothermic reactions **(1 mark)**

Increases the yield of ammonia **(1mark)**

The reaction that produces the solid sodium hydrogencarbonate involves the following equilibrium:

$$HCO_3^-(aq) + Na^+(aq) \rightleftharpoons NaHCO_3(s)$$

Brine is a concentrated sodium chloride solution.

Explain fully why using a concentrated sodium chloride solution encourages production of sodium hydrogencarbonate as a solid. **2**

(Adding brine) increases sodium ion concentration hence equilibrium shifts to right **(1)**

Rate of forward reaction is increased (by addition of brine) **(1)**

Explain **fully** why increasing temperature increases the rate of a chemical reaction. **2**

Increases the number of particles with energy equal to or greater than the activation energy

OR

Increases the number of particles with (sufficient) energy to form an activated complex/to react **(1 mark)**

More successful collisions **(1 mark)**

Given an accurately known mass of oxalic acid, describe **fully** how 250 cm^3 of a standard solution of oxalic acid could be prepared.

Dissolve oxalic acid (in small volume of water) **(1 mark)**

transfer quantitatively/with rinsings/washings **(1 mark)**

fill/make up to the mark/line in a volumetric/standard flask. **(1 mark)**

Describe in detail how a burette should be prepared and set up, ready to begin the titration. 3

1 mark for rinsing the burette - rinse the burette with the **thiosulfate / required solution** / with the solution to be put in it.

2 marks (1 mark each) for any 2 of the following points
fill burette above the scale with thiosulfate solution
filter funnel used should be removed
tap opened / some solution drained to ensure no air bubbles
(thiosulfate) solution run into scale
reading should be made from bottom of meniscus

The stock solution was prepared by adding 1·00 g of zinc metal granules to 20 cm^3 of 2 mol l^{-1} sulfuric acid in a 1000 cm^3 standard flask.

$$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$$

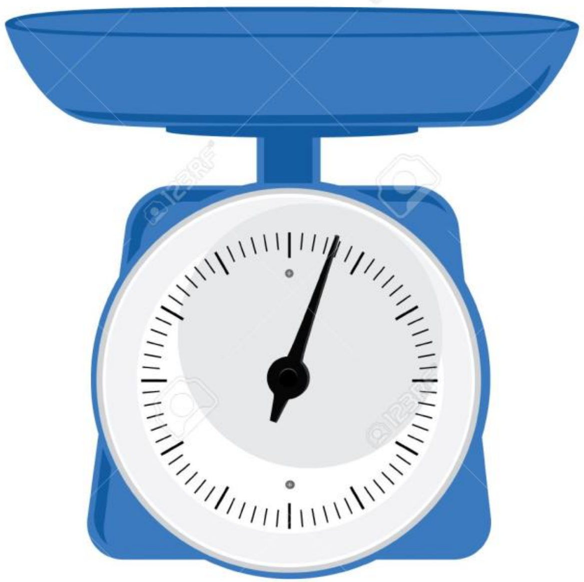
The flask was left for 24 hours, without a stopper. The solution was then diluted to 1000 cm^3 with water.

(i) **Explain fully** why the flask was left for 24 hours, without a stopper. 2

24 hours allows time for all of the zinc to react **(1)**

No stopper allows hydrogen gas to escape from the flask. **(1)**

Mass mole Calculations



Mole to mass

In one experiment, 5 sweets were dissolved, and 55 cm^3 of carbon dioxide gas was produced.

$$C_6H_8O_7(aq) + 3NaHCO_3(aq) \rightarrow 3CO_2(g) + 3H_2O(\ell) + C_6H_5O_7Na_3(aq)$$

$GFM = 192$ g

Calculate the mass of citric acid, in g, in one sweet. **2**

Take the volume of 1 mole of carbon dioxide to be 24 litres.

)	0·029 (g) **2 marks**	**2**	Uni mu

Another sample of a different seawater contained 0.00492 moles of chloride ions in a 10 cm^3 sample.

Calculate the mass of chloride ions, in grams, in one litre of seawater. **2**

17.47 g

Mass Calculation

The first step involves heating the ore with chlorine and carbon to convert titanium dioxide, TiO_2, to titanium chloride, $TiCl_4$.

$$\underset{GFM = 79.9\ \text{g}}{TiO_2} + \underset{GFM = 71.0\ \text{g}}{2Cl_2} + C \rightarrow TiCl_4 + CO_2$$

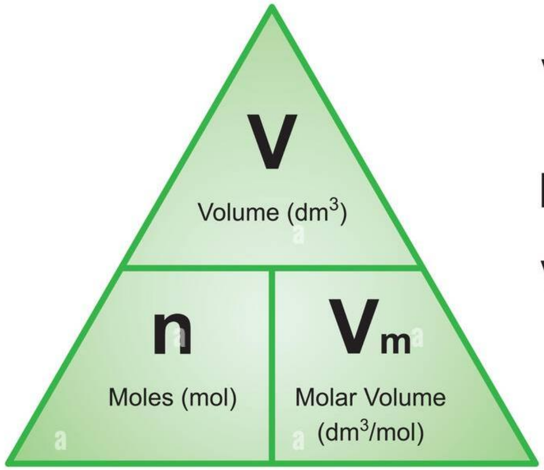
The largest reactors can process 1600 kg of titanium dioxide per day.

(i) Calculate the mass of chlorine, in kg, required to react with 1600 kg of titanium dioxide, TiO_2. **2**

2843.55 (kg)

Gas Volume Calculations

Molar Volume



$$V = n \cdot V_m$$

$$n = V : V_m$$

$$V_m = V : n$$

Molar Volume

The mixture of ethanol and water is made by fermentation followed by distillation.

In fermentation, enzymes in yeast convert glucose, $C_6H_{12}O_6$, into ethanol and carbon dioxide.

The equation for fermentation is shown.

$$C_6H_{12}O_6(aq) \rightarrow 2CH_3CH_2OH(aq) + 2CO_2(g)$$

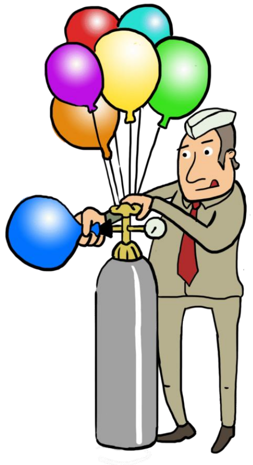
$GFM = 180$ g $\quad GFM = 46$ g $\quad GFM = 44$ g

(A) A 50.0 cm^3 sample of glucose solution contained 5.79 g of glucose.

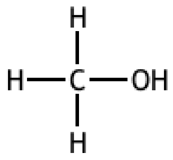
Calculate the volume, in litres, of carbon dioxide gas that would be produced if 16 litres of this glucose solution was fermented. **3**

Take the volume of 1 mole of carbon dioxide gas to be 24 litres.

494.08, 494.1, 494 (litres)



Methanol can be used as a fuel, in a variety of different ways.



(a) An increasingly common use for methanol is as an additive in petrol.

Methanol has been tested as an additive in petrol at 118 g per litre of fuel.

Calculate the volume of carbon dioxide, in litres, that would be released by combustion of 118 g of methanol.

$$2CH_3OH(\ell) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(\ell)$$

(Take the molar volume of carbon dioxide to be 24 litres mol^{-1}). **2**

118/32 or 3·69 mol CH_3OH	**(1)**
3·69 × 24 = 88·5 litres	**(1)**

Gas Volume

The first and second reactions generate the nitrogen gas needed to inflate the air bag.

For every mole of sodium azide ($GFM = 65.0$ g) that reacts, a total of 1.6 moles of nitrogen gas is formed.

Calculate the volume of gas, in litres, formed when 80 g of sodium azide reacts. **2**

Take the volume of 1 mole of nitrogen to be 24 litres.

47.26, 47.3, 47 (litres) OR 47260, 47300, 47000 (cm^3) **(2 marks)**

Fireworks were traditionally made using compounds containing the chlorate ion, ClO_3^-, as an oxidising agent.

(i) Chlorate ions release oxygen when they decompose.

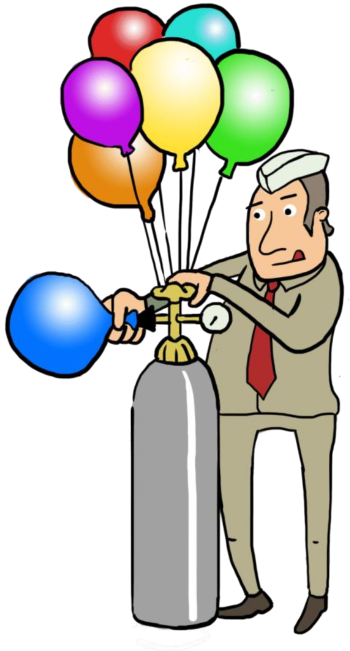
Potassium chlorate, $KClO_3$, ($GFM = 122.6$ g) reacts as shown.

$$2KClO_3(s) \rightarrow 3O_2(g) + 2KCl(s)$$

Calculate the volume of oxygen produced, in litres, when 4.6 g of potassium chlorate decomposes. **2**

Take the volume of 1 mole of oxygen gas to be 24 litres.

1.4/1.35/1.351 (litres)

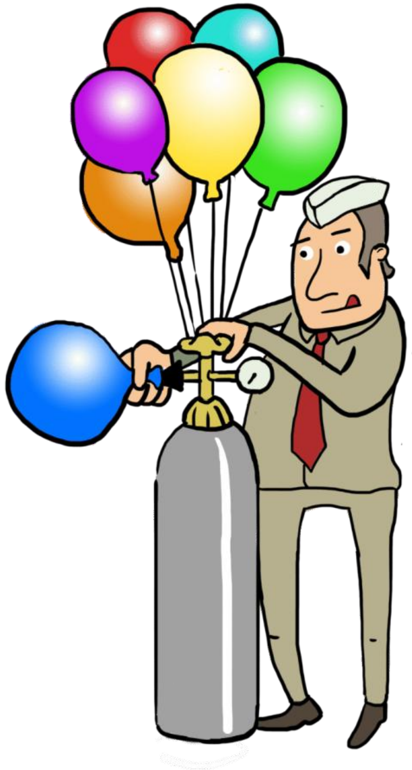


Molar Volume

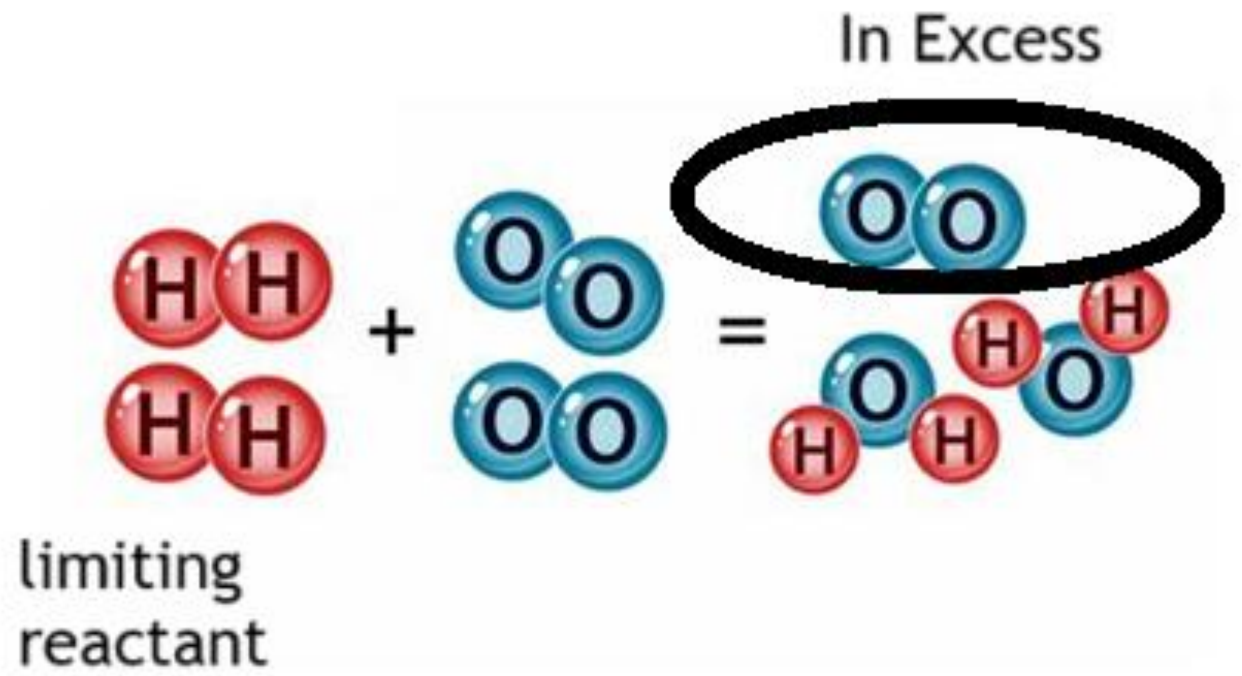
At 1500 °C, 280 g of carbon monoxide gas ($GFM = 28.0$ g) was produced and occupied a volume of 1450 litres.

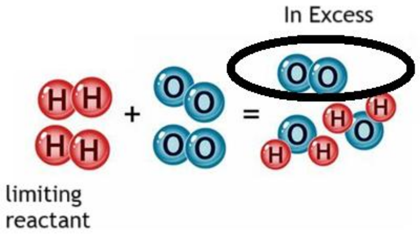
Use this information to determine the molar volume, in litres, of carbon monoxide at this temperature. **2**

145 (litres)

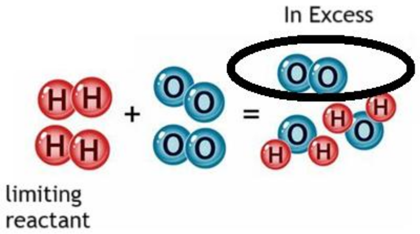


Excess Calculations





Excess Calculation



In a reaction, 1900 kg of titanium chloride was reacted with 750 kg of magnesium. Magnesium was the reactant in excess.

Calculate the number of moles of magnesium left unreacted.

10854 (moles of magnesium)

A preservative added to some fizzy drinks is made by reacting sorbic acid and potassium hydroxide.

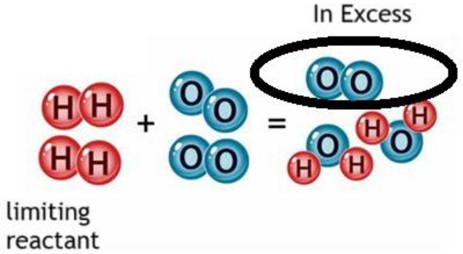
3 In an experiment, 7 g of sorbic acid, $C_6H_8O_2$, is reacted with 250 cm^3 of potassium hydroxide solution, concentration 0.5 mol l^{-1}.

$$C_6H_8O_2(s) + KOH(aq) \rightarrow H_2O(\ell) + C_6H_7O_2K(aq)$$

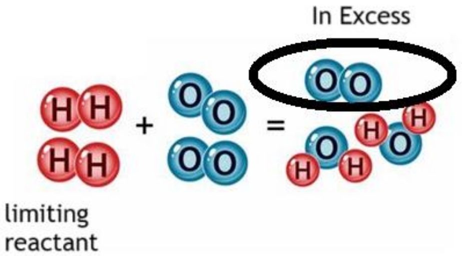
$GFM = 112$ g

Show, by calculation, that sorbic acid is the limiting reactant. 2

Correctly calculates number of moles of: Sorbic acid = 0.0625 Potassium hydroxide = 0.125	2



Excess Calculations



Nitrogen can react with lithium at room temperature to form the compound lithium nitride, Li_3N.

(i) A scientist prepared a sample of lithium nitride by reacting 0·9 litres of nitrogen gas with 0·5 g of lithium.

$$6Li(s) \quad + \quad N_2(g) \quad \rightarrow \quad 2Li_3N(s)$$

$GFM = 6{\cdot}9$ g

Determine, by calculation, which of the reactants was in excess.

Take the volume of 1 mole of nitrogen gas to be 24 litres.

(Clearly show your working for the calculation.)

stating that nitrogen is in excess or that lithium is the limiting reactant.	Correct calculation of moles of lithium = 0·07/0·072/0·0725 moles **and** nitrogen = 0·04/0·038/0·0375 moles

A student prepared a sample of methyl cinnamate from cinnamic acid and methanol.

cinnamic acid	+	methanol	→	methyl cinnamate	+	water
mass of one mole = 148 g		mass of one mole = 32 g		mass of one mole = 162 g		

6·5 g of cinnamic acid was reacted with 2·0 g of methanol.

Show, by calculation, that cinnamic acid is the limiting reactant. (One mole of cinnamic acid reacts with one mole of methanol.) **2**

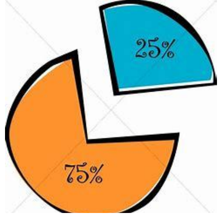
)	**1 mark** awarded for correct arithmetical calculation of moles of acid = 0·044 **and** moles alcohol = 0·063	**2**

Percentage Yield

Formula for Percent Yield

$$\text{Percent yield} = \frac{\text{Actual Yield}}{\text{Theoretical Yield}} \times 100\%$$

Percentage Yield



Phosphorus can be obtained by reacting calcium phosphate with silicon dioxide and carbon.

$$2Ca_3(PO_4)_2 \quad + \quad 6SiO_2 \quad + \quad 10C \quad \rightarrow \quad 6CaSiO_3 \quad + \quad 10CO \quad + \quad P_4$$

$GFM = 310.3$ g (for $Ca_3(PO_4)_2$) $GFM = 124.0$ g (for P_4)

(i) 750 g of calcium phosphate, $Ca_3(PO_4)_2$, produced 115.5 g of phosphorus.

Calculate the percentage yield of phosphorus, P_4. **2**

77/77.1(%)

One method of preparing silicon hydride involves reacting magnesium silicide, Mg_2Si, with hydrochloric acid, HCl.

15.32 g of magnesium silicide was reacted with excess hydrochloric acid. 2.56 g of silicon hydride was produced.

$$4HCl \quad + \quad Mg_2Si \quad \rightarrow \quad SiH_4 \quad + \quad 2MgCl_2$$

$GFM = 76.7$ g (for Mg_2Si) $GFM = 32.1$ g (for SiH_4)

Calculate the percentage yield of silicon hydride. **2**

39.9/ 40 (%) **(2 ma**

Percentage Yield

A student prepared a sample of methyl cinnamate from cinnamic acid and methanol.

cinnamic acid	+	methanol	$\rightarrow$	methyl cinnamate	+	water
mass of one mole = 148 g		mass of one mole = 32 g		mass of one mole = 162 g		

The student obtained 3·7 g of methyl cinnamate from 6·5 g of cinnamic acid.

Calculate the percentage yield. **2**

52%	**(2)**	2

A scientist prepared a sample of methyl salicylate using 28·3 g salicylic acid and an excess of reactant **X**.

$C_7H_6O_3$	+	X	$\rightarrow$	$C_8H_8O_3$	+	H_2O
salicylic acid				methyl salicylate		
$GFM = 138$ g				$GFM = 152$ g		

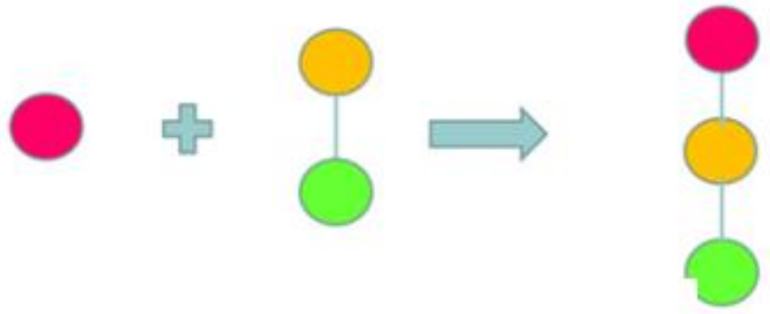
The scientist produced 24·7 g of methyl salicylate.

Calculate the percentage yield of methyl salicylate. **2**

79·24/79·2/79 (%) (2 marks)

Atom Economy

High Atom Economy



All reactant atoms included in product.

Atom Economy

The mixture of ethanol and water is made by fermentation followed by distillation.

In fermentation, enzymes in yeast convert glucose, $C_6H_{12}O_6$, into ethanol and carbon dioxide.

The equation for fermentation is shown.

$$C_6H_{12}O_6(aq) \rightarrow 2CH_3CH_2OH(aq) + 2CO_2(g)$$

$GFM = 180$ g $GFM = 46$ g $GFM = 44$ g

(B) Calculate the atom economy for the production of ethanol. **2**

12, 12.2, 12.22 (% / abv)

In the second step, titanium chloride reacts with magnesium to produce titanium metal. The reaction is carried out in a sealed vessel, in an argon atmosphere, at 1500 °C.

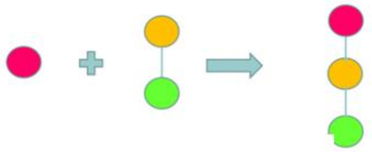
$$TiCl_4 + 2Mg \rightarrow Ti + 2MgCl_2$$

$GFM = 189.9$ g $GFM = 24.3$ g $GFM = 47.9$ g $GFM = 95.3$ g

(i) Calculate the atom economy for the production of titanium in this reaction. **2**

20%/20.1%/20.08 %

High Atom Economy



All reactant atoms included in product.

Atom Economy

Methane reacts with steam to produce hydrogen.

$CH_4(g)$	+	$H_2O(g)$	$\rightarrow$	$CO(g)$	+	$3H_2(g)$
$GFM = 16$ g		$GFM = 18$ g		$GFM = 28$ g		$GFM = 2$ g

Calculate the atom economy for the formation of hydrogen. **2**

17.647/17.65/17.6/18 (%)

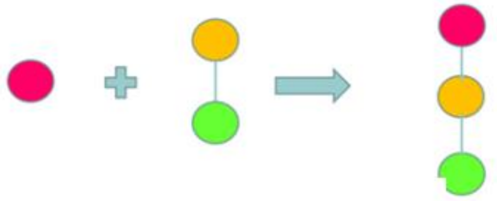
Carbon can combine with oxygen to make carbon monoxide, CO.
Carbon monoxide is used in the production of iron from iron(III) oxide.

$Fe_2O_3(s)$	+	$3CO(g)$	$\rightarrow$	$2Fe(\ell)$	+	$3CO_2(g)$
$GFM = 159{\cdot}6$ g		$GFM = 28{\cdot}0$ g		$GFM = 55{\cdot}8$ g		$GFM = 44{\cdot}0$ g

Calculate the atom economy for the production of iron. **2**

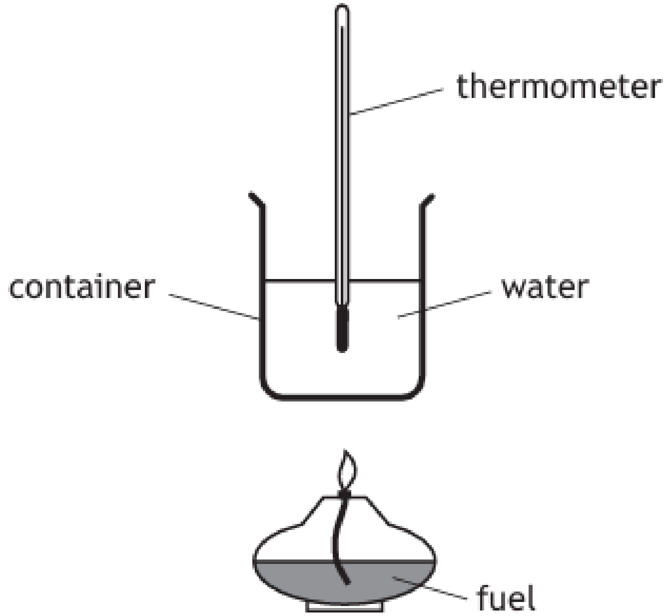
45·81/45·8/46(%) **(2 marks)**	**2**

High Atom Economy



All reactant atoms included in product.

Enthalpy of Combustion



Enthalpy of Combustion

Fats and oils release a large amount of energy when they are burned.

(i) A 1·00 g sample of the oil, triolein ($GFM = 884$ g) was burned in a bomb calorimeter.

The temperature rise in the 775 cm^3 of water was 11·9 °C.

Calculate the enthalpy of combustion, in kJ mol^{-1}, of triolein. **3**

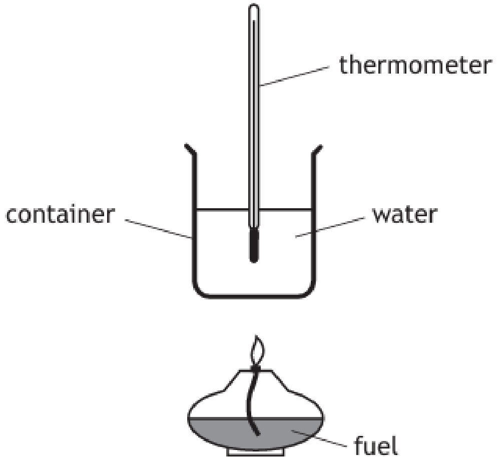
-34 078 (kJ mol^{-1})

Methane, CH_4, can be used as a fuel.

In an experiment, methane was burned to raise the temperature of 100 cm^3 of water by 27 °C.

Using the enthalpy of combustion of methane (891 kJ mol^{-1}), calculate the mass of methane, in g, burned in this experiment. **3**

0.2/0.20/0.203 g



Enthalpy of Combustion

The student's results for one type of biodiesel are shown in the table.

Mass of biodiesel burned (g)	0.420
Volume of water (cm^3)	200
Initial temperature of water (°C)	17
Final temperature of water (°C)	38

Calculate the energy released, in $kJ\,g^{-1}$, when 1.0 g of the biodiesel was burned. **3**

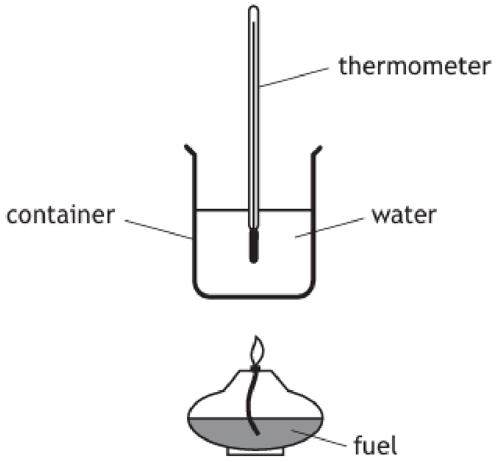
(-)41.8 ($kJ\ g^{-1}$) (3 marks)

Fats and oils release a large amount of energy when they are burned.

(i) A 1·00 g sample of the oil, triolein (GFM = 884 g) was burned in a bomb calorimeter.

The temperature rise in the 775 cm^3 of water was 11·9 °C.

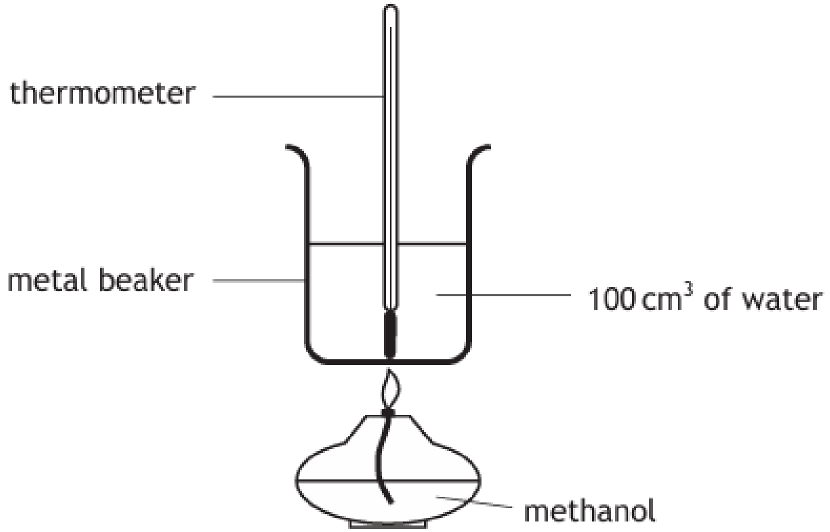
Calculate the enthalpy of combustion, in $kJ\,mol^{-1}$, of triolein. **3**



Enthalpy of Combustion

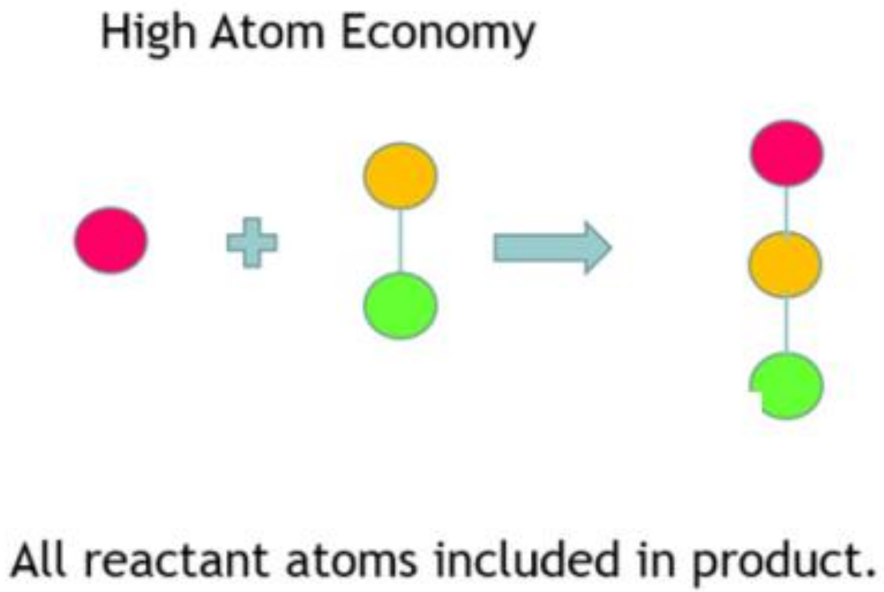
The student burned 1·07 g of methanol and recorded a temperature rise of 23 °C.

Calculate the enthalpy of combustion, in $kJ\,mol^{-1}$, for methanol using the student's results. **3**



9·61 **and** Knowledge that enthalpy of combustion relates to 1 mol **(1)** evidenced by scaling up of energy released		Units not required

Hess’s Law



Hess Law

In the United States Space Shuttle, dinitrogen tetroxide was reacted with methylhydrazine.

$$4CH_3NHNH_2(\ell) + 5N_2O_4(\ell) \rightarrow 4CO_2(g) + 12H_2O(g) + 9N_2(g)$$

Calculate the enthalpy of this reaction, in kJ, by using the data shown below. **2**

$C(s) + 3H_2(g) + N_2(g)$	$\rightarrow$ $CH_3NHNH_2(\ell)$	$\Delta H = +54$ kJ mol^{-1}
$N_2(g) + 2O_2(g)$	$\rightarrow$ $N_2O_4(\ell)$	$\Delta H = -20$ kJ mol^{-1}
$C(s) + O_2(g)$	$\rightarrow$ $CO_2(g)$	$\Delta H = -394$ kJ mol^{-1}
$H_2(g) + \frac{1}{2}O_2(g)$	$\rightarrow$ $H_2O(\ell)$	$\Delta H = -286$ kJ mol^{-1}
$H_2O(l)$	$\rightarrow$ $H_2O(g)$	$\Delta H = +41$ kJ mol^{-1}

-4632 (kJ)

Carbon monoxide can be produced by the reaction of methane and steam.

$$CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g)$$

$CO(g) + \frac{1}{2}O_2(g)$	$\rightarrow$ $CO_2(g)$	$\Delta H = -283$ kJ mol^{-1}
$H_2(g) + \frac{1}{2}O_2(g)$	$\rightarrow$ $H_2O(g)$	$\Delta H = -286$ kJ mol^{-1}
$CH_4(g) + 2O_2(g)$	$\rightarrow$ $CO_2(g) + 2H_2O(g)$	$\Delta H = -891$ kJ mol^{-1}

Calculate the enthalpy change, in kJ mol^{-1}, for this reaction. **2**

+250 kJ mol^{-1} **(2 marks)**

Hess Law

Silicon hydride, SiH_4, can be formed by reacting silicon with hydrogen.

$$Si(s) + 2H_2(g) \rightarrow SiH_4(g)$$

Calculate the enthalpy change, in kJ mol^{-1}, for this reaction using the following information. **2**

$$SiH_4(g) + 2O_2(g) \rightarrow SiO_2(s) + 2H_2O(\ell) \qquad \Delta H = -1517\ \text{kJ mol}^{-1}$$

$$Si(s) + O_2(g) \rightarrow SiO_2(s) \qquad \Delta H = -911\ \text{kJ mol}^{-1}$$

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(\ell) \qquad \Delta H = -286\ \text{kJ mol}^{-1}$$

(+) 34 (kJ mol^{-1})

Bond Enthalpy Calculations

Bond Enthalpy

) The equation for this reaction is

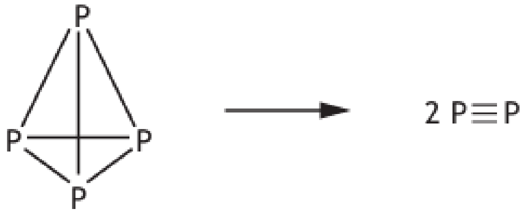
$$N\equiv N \;+\; O{=}O \longrightarrow \begin{matrix}\cdot N{=}O \\ \cdot N{=}O\end{matrix}$$

The enthalpy change, ΔH, for this reaction is $+91$ kJ mol^{-1}.

Use this data and the bond enthalpy values shown in the data booklet to calculate the bond enthalpy, in kJ mol^{-1}, of the nitrogen to oxygen double bond in nitrogen monoxide. **2**

676 (kJ mol^{-1})

At very high temperatures the following reaction occurs.



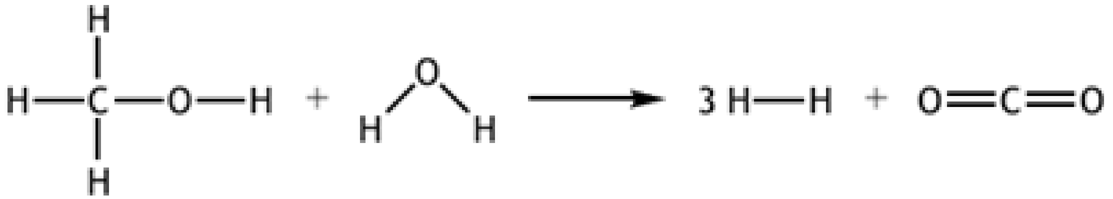
Bond	Bond enthalpy (kJ mol^{-1})
P—P	201
P≡P	488

Use the bond enthalpy values in the table to calculate the enthalpy change, in kJ mol^{-1}, for the reaction. **2**

230 (kJ mol^{-1})

Bond Enthalpy

Methanol is used as a source of hydrogen for fuel cells. The industrial process involves the reaction of methanol with steam.



Using bond enthalpies from the data booklet, calculate the enthalpy change, in $kJ\,mol^{-1}$, for the reaction of methanol with steam. **2**

(ii)	Answer = +191 $kJ\,mol^{-1}$	**(2)**

The equation for the combustion of methane is shown.

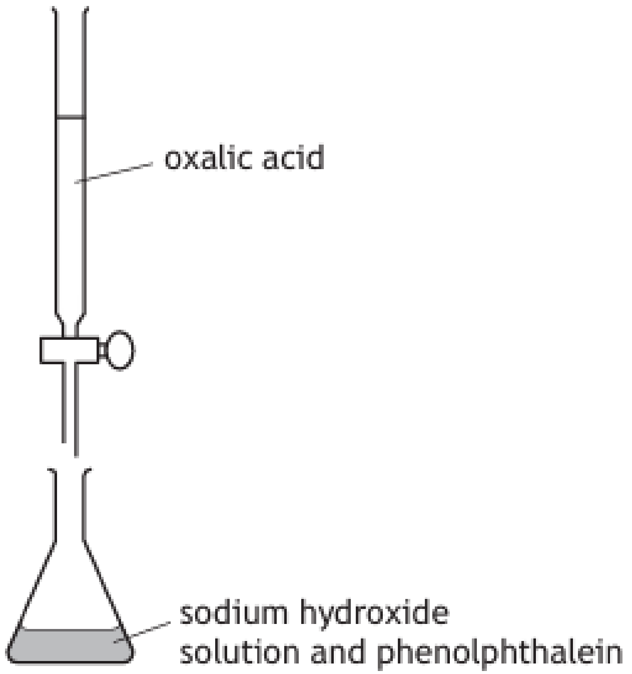
$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

Bond enthalpies can be used to calculate a theoretical enthalpy change for this reaction.

Using bond enthalpies from the data booklet, calculate the enthalpy change, in $kJ\,mol^{-1}$, for the combustion of methane.

-816 ($kJ\,mol^{-1}$)

Titration Calculations



Titration Calculation

Three 10.0 cm^3 samples of seawater were titrated with a 0.5 $mol\,l^{-1}$ silver nitrate solution.

The table shows the results obtained.

Sample	Volume of silver nitrate used (cm^3)
1	11.90
2	11.60
3	11.50

In this titration, one mole of chloride ions, $Cl^-(aq)$, reacts with one mole of silver ions, $Ag^+(aq)$.

Using the average titre value, calculate the concentration, in $mol\,l^{-1}$, of chloride ions in the seawater.

0.5775 ($mol\,l^{-1}$)

The equation for the reaction of oxalic acid and sodium hydroxide is shown.

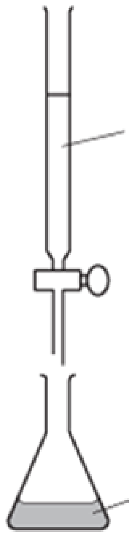
$$H_2C_2O_4(aq) \; + \; 2NaOH(aq) \; \rightarrow \; Na_2C_2O_4(aq) \; + \; 2H_2O(\ell)$$

The concentration of sodium hydroxide solution was determined by titrating 25.0 cm^3 samples with 0.126 $mol\,l^{-1}$ oxalic acid solution.

The average volume of oxalic acid solution required in the titration was 26.75 cm^3.

Calculate the concentration, in $mol\,l^{-1}$, of the sodium hydroxide.

0.27/0.3 ($mol\,l^{-1}$)



Titration

2. (a) The concentration of sodium hypochlorite in swimming pool water can be determined by redox titration.

Step 1

A 100·0 cm^3 sample from the swimming pool is first reacted with an excess of acidified potassium iodide solution forming iodine.

$$NaOCl(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow I_2(aq) + NaCl(aq) + H_2O(\ell)$$

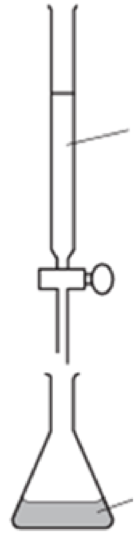
Step 2

The iodine formed in step 1 is titrated using a standard solution of sodium thiosulfate, concentration 0·00100 mol l^{-1}. A small volume of starch solution is added towards the endpoint.

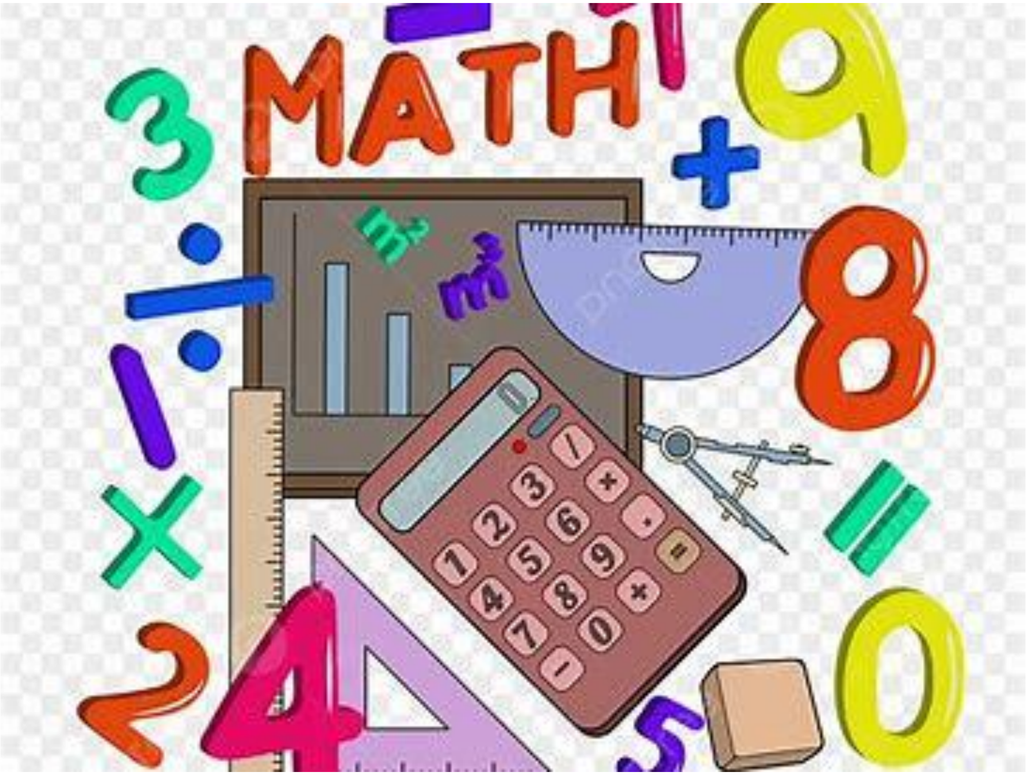
$$I_2(aq) + 2Na_2S_2O_3(aq) \rightarrow 2NaI(aq) + Na_2S_4O_6(aq)$$

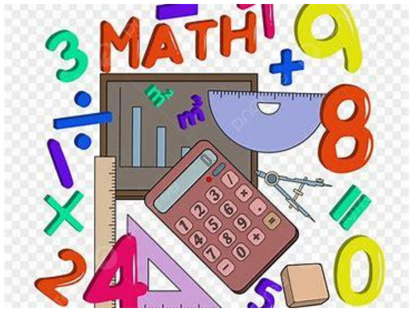
Calculate the concentration, in mol l^{-1}, of sodium hypochlorite in the swimming pool water, if an average volume of 12·4 cm^3 of sodium thiosulfate was required. **3**

0·000062 (mol l^{-1})

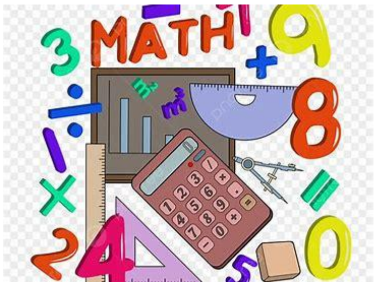


Numeracy





Numeracy



E20 is a mixture of 20% biodiesel and 80% regular diesel and is sold for use in diesel vehicles. Biodiesel costs £0.85 per litre.

Calculate the cost of the biodiesel used to produce 75 litres of E20. 1

£12.75

The salinity of seawater is a measure of the total amount of dissolved salts and can be calculated using the following formula.

Salinity (parts per thousand) = chloride ion concentration (mg l^{-1}) $\times$ 0.0018066

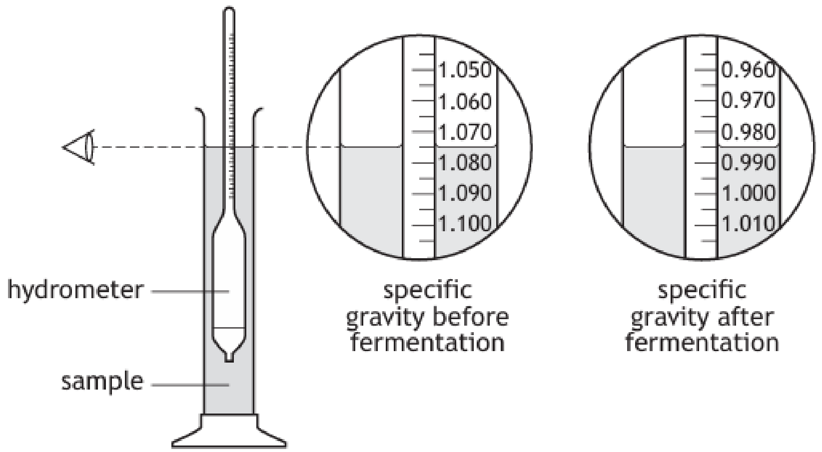
A sample of seawater had a salinity of 35 parts per thousand.

Calculate the chloride ion concentration, in g l^{-1}, of this sample. 2

19/19.4/19.37 (g l^{-1})

) The percentage of alcohol by volume can be calculated by measuring the specific gravity of samples taken before and after fermentation.

The specific gravity is measured using a hydrometer. The level of the sample on the hydrometer scale, read at eye level, is the specific gravity.



The % alcohol by volume can be calculated using the formula

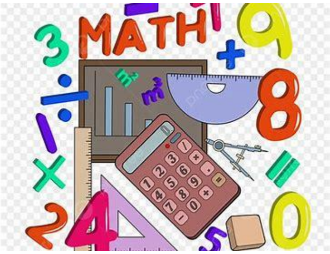
$$\%\text{ alcohol by volume} = \left(\frac{\text{change in specific gravity}}{0.7362}\right) \times 100$$

Calculate the % alcohol by volume for this sample.

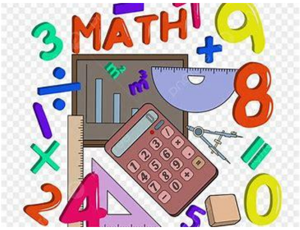
12, 12.2, 12.22 (% / abv)

Partial mark for correctly calculated change in specific gravity.
1.075-0.985 or 0.09. **(1 mark)**

Partial mark for correctly calculated value using an incorrect value for change in specific gravity. **(1 mark)**



Numeracy



Gin is often mixed with tonic water before drinking. Tonic water contains quinine, a bitter tasting compound. Historically quinine was used to treat malaria.

To treat malaria an intake of 10.0 mg of quinine per kilogram of body weight is required every 8 hours.

Calculate the mass of quinine required by a 70 kg adult in one day. 2

2100 **(1 mark)** mg **(1 mark)**

OR

2·1 **(1 mark)** g **(1 mark)**

OR

0·0021 **(1 mark)** kg **(1 mark)**

100 cm^3 of mouthwash contains 1·5 g of 35% hydrogen peroxide solution.

A 35% hydrogen peroxide solution contains 35 g of hydrogen peroxide in 100 cm^3 of solution.

(i) Calculate the mass of hydrogen peroxide, in g, present in a 300 cm^3 bottle of the mouthwash. 1

1.6

Foods with a lower respiratory quotient are better for people who find it difficult to obtain energy from food.

The respiratory quotient, RQ, is the ratio of carbon dioxide, CO_2, produced to the oxygen, O_2, consumed when a food is burned in the body.

$$\text{Respiratory quotient} = \frac{CO_2 \text{ produced}}{O_2 \text{ consumed}}$$

The equation for the combustion of triolein, $C_{57}H_{104}O_6$, is shown.

$$C_{57}H_{104}O_6(\ell) + 80\ O_2(g) \rightarrow 57\ CO_2(g) + 52\ H_2O(\ell)$$

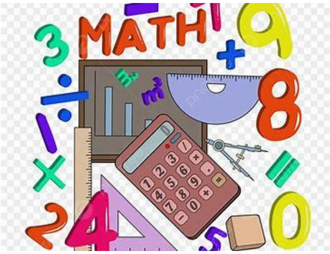
Determine the respiratory quotient for triolein. 1

0·71/0.713/0.7125

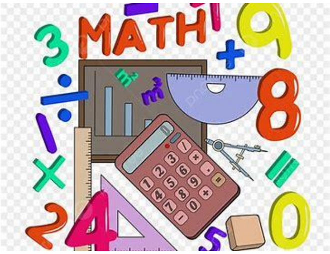
1 kg of natural vanillin costs £1050. To make a packet of sweets, 5 cm^3 of vanillin solution is used. This contains 0·184 g of vanillin per 100 cm^3 of solution.

Calculate the cost, in pence, of the natural vanillin required to make the packet of sweets. 2

1p



Numeracy



One type of seaweed contains 0·133 g of iodine per kilogram of seaweed.

The World Health Organisation recommends a daily intake of iodine of 0·15 mg.

Calculate the mass of seaweed that would provide the recommended daily intake. 2

1.13

Unlike sweet potatoes, white potatoes contain the chemical solanine, that can be toxic to humans in large doses. A dose of 3 mg per kg of body weight can cause toxic symptoms.

A typical white potato can contain 0.2 mg per g of solanine.

Calculate the mass of white potato that could produce a toxic dose to an adult weighing 65 kg. 3

975

Ammonium ferric citrate ($GFM = 261.8$ g) gives some drinks a characteristic orange colour. A typical drink contains 0.002% of ammonium ferric citrate.

A 1% solution contains 1 g made up to 100 cm^3 of solution.

Calculate the number of moles of ammonium ferric citrate required to make 330 cm^3 of this fizzy drink.

0.0000252

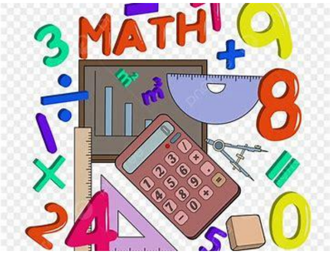
) The student wanted to scale up the experiment to make 100 g of methyl cinnamate.

2

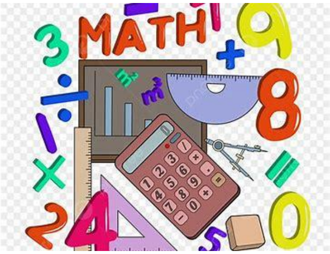
Cinnamic acid costs £35·00 per 250 g.

Calculate the cost of cinnamic acid needed to produce 100 g of methyl cinnamate. 2

24.59



Numeracy



Coumarin is another compound found in the brand name perfume. It is present in the spice cinnamon and can be harmful if eaten in large quantities.

The European Food Safety Authority gives a tolerable daily intake of coumarin at 0·10 mg per kilogram of body weight.

1·0 kg of cinnamon powder from a particular source contains 4·4 g of coumarin. Calculate the mass of cinnamon powder, in g, which would need to be consumed by an adult weighing 75 kg to reach the tolerable daily intake. **2**

1.7

The level of hypochlorite in swimming pools needs to be maintained between 1 and 3 parts per million (1 – 3 ppm).

400 cm^3 of a commercial hypochlorite solution will raise the hypochlorite level of 45 000 litres of water by 1 ppm.

Calculate the volume of hypochlorite solution that will need to be added to an Olympic-sized swimming pool, capacity 2 500 000 litres, to raise the hypochlorite level from 1 ppm to 3 ppm. **2**

44.4

The student determined the density of the alcohols by measuring the mass of a volume of each alcohol.

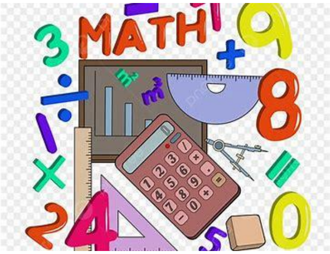
The student's results are shown below.

	Methanol	*Ethanol*
Volume of alcohol (cm^3)	25·0	25·0
Mass of alcohol (g)	19·98	20·05
Density of alcohol ($g\,cm^{-3}$)		0·802

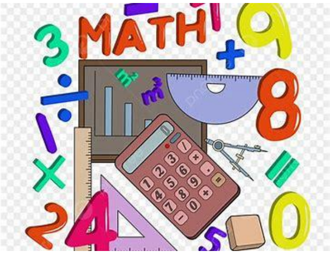
Calculate the density, in $g\,cm^{-3}$, of methanol. **1**

0.799

Calculate the concentration, in $mg\,l^{-1}$, of the solution prepared by transferring $10\,cm^3$ of the $1\,g\,l^{-1}$ stock solution to a $1000\,cm^3$ standard flask and making up to the mark. **1**



Numeracy



The minimum concentration of ethanethiol in air that can be detected by humans is $2{\cdot}7 \times 10^{-7}$ mg per cm^3 of air.

Calculate the minimum mass of ethanethiol that needs to be present in a room containing 43 900 litres of air in order for it to be detected. 2

11.853

An affected animal must be treated with 9 doses of 20% ethanol solution. Each dose contains 5 cm^3 of the ethanol solution for every kilogram body mass of the animal.

Calculate the total volume, in cm^3, of the 20% ethanol solution needed to treat a 3·5 kg animal. 1

157.5

Squalene, a triterpene, is included in some flu vaccines to enhance the body's immune response. A single dose of flu vaccine contains 10·69 mg of squalene.

Calculate the mass of squalene required to produce a batch of 500 000 doses of flu vaccine.

Your answer must be given in kg. 2

5.345