Year 10 Science 2026
Chemistry
Fuels
Student Booklet 2

Name:________________________________

	2026 Yr10 Chemistry Course Objectives	**Bold = ext only** **keywords**
	During this unit represent reactions using word and balanced formula equations, including state symbols.	
Atomic Structure (revision)	Draw and describe the model of an atom using a labelled diagram. Include the terms: protons, neutrons, electrons, nucleus, energy levels (shells) and cloud of electrons.	atom, proton, neutron, electron, shell
	Recall the properties of charge and mass to the atomic structure.	positive, neutral, negative
	Draw an energy level diagram and the electron configuration for the first 20 elements.	electron configuration, orbit (shell)
	Understand how the electron configuration of an atom determines its position in the Periodic Table and its valency.	
	Describe an isotope and why elements on the Periodic table do not have whole mass numbers.	isotope, mass number, relative atomic mass
Bonding	Understand the difference between an ionic bond and a covalent bond. **Recognise which bonds are present in a chemical.**	ionic bond, covalent bond, ionic compound, molecules
Combustion and Fuels	State the definition of a fuel.	fuel
	Name, write the formulae and draw the structure for the first five alkanes and alkenes, **including isomers.**	alkane, alkene, hydrocarbon, saturated, unsaturated, single bond, double bond, structural formula, **isomers, isomerism**
	Write chemical equations for the complete combustion of a hydrocarbon. Including the use of the appropriate state symbol for water.	Incomplete/complete combustion
	State the products of incomplete combustion.	
	Explain why incomplete combustion produces carbon monoxide and carbon.	
	Describe how carbon monoxide behaves as a toxic gas.	toxic, haemoglobin
	Complete a practical to determine the energy content of fuels.	fuel, combustion, ignition, energy.
	Calculate the energy emitted/absorbed during chemical reactions, such as combustion.	exothermic, endothermic
	Draw and interpret simple graphical representations of energy changes occurring in chemical reactions.	
Climate Change	Explain how greenhouse gases (e.g. carbon dioxide, methane, water, nitrous oxide) can lead to climate change.	emit, reflect, absorb, thermal energy, **thermal equilibrium, infra-red radiation**
	Briefly describe the processes of carbon dioxide sequestration (removal and storage) and understand this as a method to slow down the increase of atmospheric carbon dioxide.	carbon dioxide sequestration – biomass, ocean acidification

Alternative fuels	Describe some of the advantages and disadvantages of biofuels (bioethanol and biodiesel) as an alternative to crude oil.	
	Describe the advantages and disadvantages of using hydrogen gas as a fuel.	
Reactivity of Metals	Understand that metals can be arranged in their order of reactivity.	
	Use chemical equations, including state symbols, to describe the reactions of metals with a) oxygen b) dilute acids (hydrochloric, sulfuric, nitric)	
	Understand how less reactive metals can be displaced from their ore by more reactive ones. Use chemical equations to describe these reactions.	
	Explain that unreactive metals form 'weak' compounds that decompose when heated. Use chemical equations to describe the reactions of metal carbonates when heated.	
	Use the reactivity series to predict displacement reactions. Use word and balanced equations to describe the reactions of metal displacement reactions.	
	Write ionic equations for displacement reactions.	
	Use the atomic structure to explain why some metals are more reactive than others.	
Rates of Reactions *(Term 4 – not tested in S1 exams)*	State the kinetic theory of matter and the collision theory.	kinetic theory of matter, collision theory
(Term 4 – not tested in S1 exams)	List the factors that can control the rate of a chemical reaction: surface area, concentration, temperature, mixing/stirring, **catalyst.**	concentration, **catalyst enzyme**
(Term 4 – not tested in S1 exams)	Explain how the different factors (listed above) can affect the rate of reaction and how these are related to the collision theory.	

1. Periodic table of the elements

Key: atomic number — 79; symbol of element — Au; relative atomic mass — 197.0; name of element — gold

1 **H** 1.0 hydrogen																	2 **He** 4.0 helium
3 **Li** 6.9 lithium	4 **Be** 9.0 beryllium											5 **B** 10.8 boron	6 **C** 12.0 carbon	7 **N** 14.0 nitrogen	8 **O** 16.0 oxygen	9 **F** 19.0 fluorine	10 **Ne** 20.2 neon
11 **Na** 23.0 sodium	12 **Mg** 24.3 magnesium											13 **Al** 27.0 aluminium	14 **Si** 28.1 silicon	15 **P** 31.0 phosphorus	16 **S** 32.1 sulfur	17 **Cl** 35.5 chlorine	18 **Ar** 39.9 argon
19 **K** 39.1 potassium	20 **Ca** 40.1 calcium	21 **Sc** 45.0 scandium	22 **Ti** 47.9 titanium	23 **V** 50.9 vanadium	24 **Cr** 52.0 chromium	25 **Mn** 54.9 manganese	26 **Fe** 55.8 iron	27 **Co** 58.9 cobalt	28 **Ni** 58.7 nickel	29 **Cu** 63.5 copper	30 **Zn** 65.4 zinc	31 **Ga** 69.7 gallium	32 **Ge** 72.6 germanium	33 **As** 74.9 arsenic	34 **Se** 79.0 selenium	35 **Br** 79.9 bromine	36 **Kr** 83.8 krypton
37 **Rb** 85.5 rubidium	38 **Sr** 87.6 strontium	39 **Y** 88.9 yttrium	40 **Zr** 91.2 zirconium	41 **Nb** 92.9 niobium	42 **Mo** 96.0 molybdenum	43 **Tc** (98) technetium	44 **Ru** 101.1 ruthenium	45 **Rh** 102.9 rhodium	46 **Pd** 106.4 palladium	47 **Ag** 107.9 silver	48 **Cd** 112.4 cadmium	49 **In** 114.8 indium	50 **Sn** 118.7 tin	51 **Sb** 121.8 antimony	52 **Te** 127.6 tellurium	53 **I** 126.9 iodine	54 **Xe** 131.3 xenon
55 **Cs** 132.9 caesium	56 **Ba** 137.3 barium	**57–71** lanthanoids	72 **Hf** 178.5 hafnium	73 **Ta** 180.9 tantalum	74 **W** 183.8 tungsten	75 **Re** 186.2 rhenium	76 **Os** 190.2 osmium	77 **Ir** 192.2 iridium	78 **Pt** 195.1 platinum	79 **Au** 197.0 gold	80 **Hg** 200.6 mercury	81 **Tl** 204.4 thallium	82 **Pb** 207.2 lead	83 **Bi** 209.0 bismuth	84 **Po** (210) polonium	85 **At** (210) astatine	86 **Rn** (222) radon
87 **Fr** (223) francium	88 **Ra** (226) radium	**89–103** actinoids	104 **Rf** (261) rutherfordium	105 **Db** (262) dubnium	106 **Sg** (266) seaborgium	107 **Bh** (264) bohrium	108 **Hs** (267) hassium	109 **Mt** (268) meitnerium	110 **Ds** (271) darmstadtium	111 **Rg** (272) roentgenium	112 **Cn** (285) copernicium		114 **Fl** (289) flerovium		116 **Lv** (292) livermorium		

57 **La** 138.9 lanthanum	58 **Ce** 140.1 cerium	59 **Pr** 140.9 praseodymium	60 **Nd** 144.2 neodymium	61 **Pm** (145) promethium	62 **Sm** 150.4 samarium	63 **Eu** 152.0 europium	64 **Gd** 157.3 gadolinium	65 **Tb** 158.9 terbium	66 **Dy** 162.5 dysprosium	67 **Ho** 164.9 holmium	68 **Er** 167.3 erbium	69 **Tm** 168.9 thulium	70 **Yb** 173.1 ytterbium	71 **Lu** 175.0 lutetium

89 **Ac** (227) actinium	90 **Th** 232.0 thorium	91 **Pa** 231.0 protactinium	92 **U** 238.0 uranium	93 **Np** (237) neptunium	94 **Pu** (244) plutonium	95 **Am** (243) americium	96 **Cm** (247) curium	97 **Bk** (247) berkelium	98 **Cf** (251) californium	99 **Es** (252) einsteinium	100 **Fm** (257) fermium	101 **Md** (258) mendelevium	102 **No** (259) nobelium	103 **Lr** (262) lawrencium

The value in brackets indicates the mass number of the longest-lived isotope.

TURN OVER

Formulas and charges for selected ions

Cations

1+		2+		3+	
Name	**Formula**	**Name**	**Formula**	**Name**	**Formula**
ammonium	NH_4^+	barium	Ba^{2+}	aluminium	Al^{3+}
copper(I)	Cu^+	calcium	Ca^{2+}	chromium(III)	Cr^{3+}
hydronium	H_3O^+	copper(II)	Cu^{2+}	iron(III)	Fe^{3+}
lithium	Li^+	iron(II)	Fe^{2+}	**4+**	
potassium	K^+	lead(II)	Pb^{2+}	titanium(IV)	Ti^{4+}
silver	Ag^+	magnesium	Mg^{2+}		
sodium	Na^+	mercury(II)	Hg^{2+}		
		nickel(II)	Ni^{2+}		
		tin(II)	Sn^{2+}		
		zinc	Zn^{2+}		

Anions

1−		2−		3−	
Name	**Formula**	**Name**	**Formula**	**Name**	**Formula**
bromide	Br^-	carbonate	CO_3^{2-}	citrate	$C_6H_5O_7^{3-}$
chlorate	ClO_3^-	chromate	CrO_4^{2-}	nitride	N^{3-}
chloride	Cl^-	dichromate	$Cr_2O_7^{2-}$	phosphate	PO_4^{3-}
chlorite	ClO_2^-	monohydrogen phosphate	HPO_4^{2-}		
cyanide	CN^-	oxide	O^{2-}		
dihydrogen phosphate	$H_2PO_4^-$	peroxide	O_2^{2-}		
ethanoate	CH_3COO^-	sulfate	SO_4^{2-}		
fluoride	F^-	sulfide	S^{2-}		
hydrogen carbonate	HCO_3^-	sulfite	SO_3^{2-}		
hydrogen sulfate	HSO_4^-	thiosulfate	$S_2O_3^{2-}$		
hydrogen sulfide	HS^-				
hydrogen sulfite	HSO_3^-				
hydroxide	OH^-				
hypochlorite	ClO^-				
iodide	I^-				
nitrate	NO_3^-				
nitrite	NO_2^-				
perchlorate	ClO_4^-				
permanganate	MnO_4^-				

Fuels and Combustion

Learning Objective:
State the definition of a fuel. Write chemical equations for the complete combustion of a hydrocarbon.

Complete Combustion

General equation: fuel + oxygen → carbon dioxide + water

- a **fuel** is a material that **burns** to release heat (**exothermic reaction)**
- to combust (burn) it requires **oxygen.**
- **combustion** is an **oxidation reaction**
- **complete combustion** occurs when there is **enough oxygen for something to burn completely**
- the products of **complete** combustion of a hydrocarbon are **always** carbon dioxide and water

Fuels

- A fuel is a substance that ______________________________________
- All hydrocarbon molecules contain **only** the elements

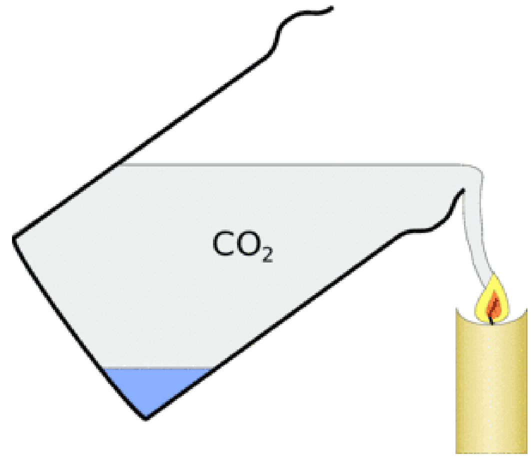
  ____________________ and ___________________.
- When a fuel burns completely (complete combustion) it produces

  ______________________________and ____________.
- When a fuel burns the chemical contained in the fuel is released as

  ___________________ energy.
- Reactions that give out this type of energy are known as

  ____________________ reactions.

CO_2 Fire Extinguisher Experiment



Carbon dioxide (CO_2) is a colourless gas that humans encounter routinely, as it is a byproduct of respiration and combustion processes, such as those occurring in vehicle engines. It plays a critical role in photosynthesis, enabling plants to convert light energy into chemical energy. Being denser than air, carbon dioxide can displace oxygen and is effective in extinguishing certain classes of fires. It can also be used in creative ways to put out a flame.

Aim

____

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Prediction – <u>explain</u> what you think will happen

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Materials

600mL beaker	50 mL Vinegar (ethanoic acid)	5 tea lights
100mL beaker	20 g of bicarbonate soda	1 lighter
1 Tub	1 digital scale and 1 patty pan	1 heatproof mat

Method

1. Set up 5 tea light candles, in a row, on the heatproof mat.
2. Measure out 20 g of bicarbonate soda in a patty pan on the digital scale, then pour it into the 600 mL beaker and place the beaker in the tub.
3. Measure out 50mL of vinegar in the 100 mL beaker.
4. Light the 5 candles with a lighter.
5. Slowly pour the 50mL of vinegar into the 600mL beaker.
6. Once the reaction has taken place, pick up the beaker and tilt it so the CO_2 gas is slowly waved over the candles. Note - keep the liquid in the beaker!
7. Observe what happens.

DISCUSSION:

Describe your <u>observations</u> from the experiment.

Explain why this happened using what you know about the properties of carbon dioxide.

Describe how the experiment could have been improved.
Consider:

- Were all the flames extinguished? If not, why not?
- Was any liquid spilled? If so, how could this be avoided next time?
- How could your teamwork be improved? Be specific.

Complete Combustion Reactions

Write word and balanced chemical equations for the complete combustion of the following fuels.

1. Using a barbeque that contains the portable fuel called *propane,* C_3H_8

Word equation:

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Balanced Chemical Equation:

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2. Cars use petrol – the fuel in petrol is mainly *octane,* C_8H_{18}

Word equation:

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Balanced Chemical Equation:

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3. Planes use a kerosene fuel mixture. This mixture includes the fuel *decane*, $C_{10}H_{22}$

Word equation:

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Balanced Chemical Equation:

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4. SpaceX's Starship rocket is being developed to take man to Mars. It uses the fuel *methane*, CH_4

Word equation:

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Balanced Chemical Equation:

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5. Respiration is occurring in every cell of your body. (fuel = *glucose* $C_6H_{12}O_6$)

Word equation:

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Balanced Chemical Equation:

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6. Some cars use hydrogen as fuel. How is the combustion of hydrogen different to the other fuels?

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Learning Objective:
State the products of incomplete combustion. Explain why incomplete combustion produces carbon monoxide and carbon. Describe how carbon monoxide behaves as a toxic gas.

Incomplete Combustion

- occurs when there isn't enough oxygen for something to burn completely.
- produces carbon, C (black soot) and/or carbon monoxide, CO.
- water is always produced.

fuel + oxygen --> carbon monoxide + carbon + water

Tragic mum's campaign after sons' deaths from silent killer

LIFE will never be the same for the eternally grieving Victorian mum Vanessa Robinson. But years after losing both her sons to carbon monoxide poisoning, she's more determined than ever to raise awareness of the silent killer.

Leesa Smith

kidspot MAY 8, 2018 1:05PM

IT WASN'T uncommon for Vanessa to have her boys sneak into her bed for a snuggle in the middle of the night.

So when Chase, 8, and Tyler, 6, did just this on May 30 in 2010 — she thought nothing of it.

"The boys came into my room in the early hours of the morning, which wasn't unusual being a single mother. They were crying and I thought one had a nightmare and therefore upset the other. We cuddled and went to sleep," she tells Kidspot.

The Melbourne mum-of-two could not have possibly known that this would be the very last time she would be able to hold her beautiful boys in her arms ever again.

Vanessa felt let down by the government for not creating public awareness about carbon monoxide poisoning. *Source:Supplied*

"I remember being in an incredible amount of pain, drifting in and out of consciousness until a constant ringing woke me. I was dazed and confused, and I couldn't move my left arm. I noticed that something was very wrong with Chase and Tyler and called the ambulance and my ex-husband," she said.

"We had lost an entire day and woke up around 6pm on Sunday night. I think subconsciously I knew my children had died, but it took a long time to process it properly."

It wasn't confirmed until two days after that tragic night that Vanessa's boys had died from carbon monoxide poisoning from a gas heater leak in the lounge room down the other end of their rental house.

But Vanessa was fighting for her own life to be able to truly grasp the enormity of the situation.

"It took a long time to process, as I was put in an induced coma and had renal failure and other injuries from the carbon monoxide poisoning," she says. "When I woke up in ICU at St Vincent's hospital, I remember crying and saying to my mother that they had died. But saying that, it still didn't register properly for a long time. I'm thankful that I was quite unwell, as if I wasn't I really don't know how I would have lived through that much trauma while being fully conscious of what had happened."

Carbon monoxide poisoning detection

After taking several months in hospital to recover — Vanessa was incredibly lucky to survive — the heartbreaking reality hit hard.

Vanessa Robinson is tirelessly campaigning for community safety. Picture: Jake Nowakowski *Source:News Corp Australia*

"Once I was able to comprehend, I was angry, in shock and appalled that this could happen to my family. I just could not understand why such a significant threat to health and life was not even on the government's agenda to bring awareness to the Australian public," she says. "Since campaigning and starting the *Chase and Tyler Foundation*, we've realised that the issue is more of an epidemic and many community members have been exposed and have been and are currently at risk." Vanessa implores every household to install a CO alarm and make sure you regularly service your household appliances.

Read and use the Victoria Information booklet on ACGS **"Beware carbon monoxide – it's a silent killer'** to answer the following questions. *Answer the following questions:*

Questions

1. Describe the properties of carbon monoxide (C) gas. Why is it called the "silent killer"?

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2. When might carbon monoxide be produced?

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3. Carbon monoxide is a toxic (deadly) gas, list some of the symptoms that we might see if a person is suffering from carbon monoxide poisoning.

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4. Why might a gas heater produce carbon monoxide?

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5. Give 2 signs that a gas heater maybe faulty.

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6. Having your gas heater serviced ensures that is working properly and not emitting carbon monoxide. When renting accommodation your landlord should be able to show you a certificate detailing when the gas heater was last serviced. How often should you have a gas heater serviced?

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7. Portable gas appliances use LPG (liquified petroleum gas). Why are burning these inside an enclosed area, for instance a tent or car, dangerous?

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8. Find out, and write a description, to explain why carbon monoxide is a deadly gas. *Include the words haemoglobin and oxyhaemoglobin in your description.*

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Carbon Monoxide and Traffic

A group of students in a city school have been given three carbon monoxide measuring monitors (A, B and C).

First, they tested the air in the school playground.
Then they went outside the school and took some more readings by a busy roundabout.

The students predicted that they would find higher carbon monoxide concentrations near the roundabout because incomplete combustion occurs in vehicle engines.

Table 1 Carbon monoxide readings in the playground

Monitor	Playground readings (ppm*)				
	1	2	3	4	Mean
A	2.3	2.1	1.9	2.1	
B	2.1	2.0	1.1	1.9	
C	2.0	1.9	2.2	3.4	
				Overall mean	

* 'ppm' means parts per million

Table 2 CO readings at the roundabout

Monitor	Roundabout readings (ppm)				
	1	2	3	4	Mean
A	7.6	7.2	7.1	7.4	
B	7.1	7.3	6.9	5.5	
C	6.8	7.2	8.9	7.0	
				Overall mean	

1. What is the formula of carbon monoxide?

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2. a) Explain how carbon monoxide is produced in car engines.

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____

b) Explain why it is dangerous to leave a car running in a garage with the door shut.

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3. Look at the measurements in Tables 1 and 2. Outliers are measurements that do not seem to fit the pattern of other measurements that are taken.

   a) In the table above, put a ring around the readings that could be outliers.

   b) Suggest why there are outliers.

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4. Leaving out the outliers, work out the mean reading for each instrument in the two locations. Write down the mean reading for each instrument in the table above.

5. Calculate the overall mean amount of carbon monoxide in the two locations. Write your answers in the last row of each table above.

6. Use the mean values to write a conclusion for the investigation.

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Hydrocarbon Molecules

Learning Objective:
Name, write the formulae and **draw the structure** for the first five alkanes and alkenes, **including isomers. Compare the alkanes and alkenes.**

The Alkanes General formula =

Name	Formula	Structure	Isomers (EXT)

For both ethane and propane, write a word and balanced equation, including state symbols to show the reaction when they burn in air.

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The Alkenes General formula =

Name	Formula	Structure	Isomers

Core Research: Why are alkenes so important to us?

EXT: In your exercise book, write a description (or draw a table) to **compare** the alkanes and alkenes.

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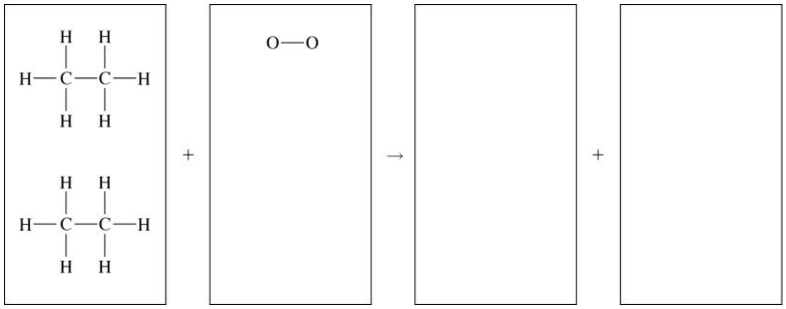
Complete Combustion Questions

1. The diagram shows two molecules of a fuel called ethane and a molecule of oxygen.



a. What are the products formed when ethane burns in excess (more than enough) air?

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b. Write a word equation for the combustion of ethane.

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c. Write a chemical equation showing the formulae of the reactants and products (this does not have to be balanced).

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d. How many carbon atoms are there altogether in the two ethane molecules?

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e. How many carbon dioxide molecules will be formed from the two ethane molecules?

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f. Draw the correct number of carbon dioxide molecules in one of the empty boxes.

g. How many hydrogen atoms are there altogether in the two ethane molecules?

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h. How many water molecules will these make?

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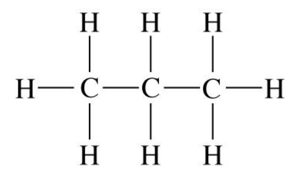
i. Draw the water molecules in the remaining empty box.

j. Count the number of oxygen atoms in all the carbon dioxide and water molecules you have drawn. Draw more oxygen molecules in the second box until you have the right number. *Remember to draw oxygen molecules, not atoms.*

k. Balance the formula equation by writing the correct numbers in front of the formulae you wrote in part **c**.

3. The drawing shows a molecule of propane.
   Write a balanced equation for the combustion of propane.



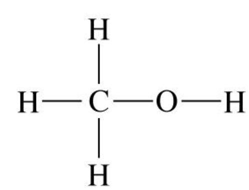
3. Write balanced equations for the combustion of the following hydrocarbons:

a) C_4H_{10}

b) C_5H_{12}

c) C_6H_{14}

4. The drawing shows a molecule of an alcohol called methanol.

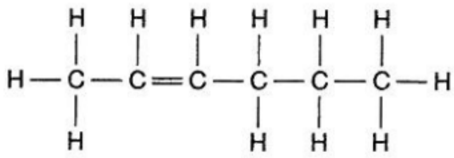


a) Is methanol a hydrocarbon? Explain your answer.

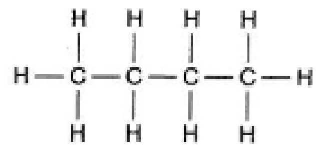
b) Alcohols also produce carbon dioxide and water when they burn completely in excess oxygen. Write a balanced equation for the combustion of methanol.

Families of hydrocarbons -Alkanes and Alkenes

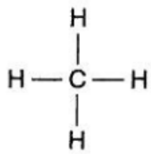
A.



E.



B.



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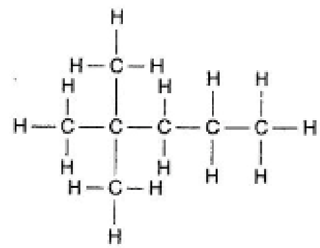
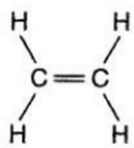
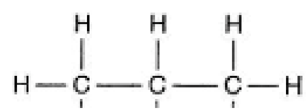


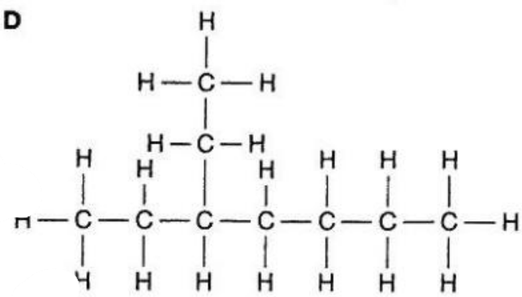
C.



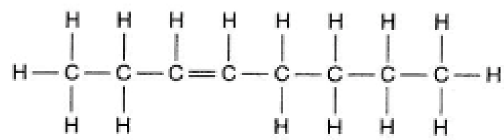
G.



D



H.



1. List the letters of all compounds that are alkanes.

2. List the letters of all compounds that are alkenes.

3. Summarise the meaning of the term homologous series.

4. List the letters of all compounds that are unsaturated.

5. List the letters of all compounds that are saturated.

____

6. Give the systematic name of each compound.

A. ____________________________

C. ____________________________

E. ____________________________

H. ____________________________

7. Identify the compound you would expect to have the lowest boiling temperature and explain your answer.

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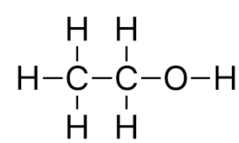
8. Draw the structure of the two members of the same homologous series that follow the molecule with the condensed formula CH_3CH_2OH.



Which petrol should I use?!

At the petrol pump there are usually three fuels that

you can choose from:

98 octane, 95 octane and 91 octane.

Use the following websites to help answer some of the questions below and to note any points of interest.

https://www.canstarblue.com.au/vehicles/which-petrol-should-you-use/
https://www.caradvice.com.au/696275/which-fuel-type-do-i-need-petrol-diesel-e10-lpg-whats-the-difference/

1. What is the chemical formula for octane? ___________________________________

2. Find out what the difference is between the following petrol choices: 98 octane, 95 octane and 91 octane.

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3. 98 octane is the most expensive, some car manufacturers will suggest that you use this petrol in your car engine. Are they justified in suggesting this?

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4. Alternatively, some manufacturers will suggest that 91 octane petrol is sufficient. Is it ‘better’ to fill up your car with the more expensive 98 octane petrol?

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Energy Changes in a Chemical Reaction

Learning Objective:
Complete a practical to determine the energy content of fuels.
Calculate the energy emitted/absorbed during chemical reactions, such as combustion. **Draw and interpret simple graphical representations of energy changes occurring in chemical reactions.**

Which Fuel is 'best'? Fuels are substances that are burned to obtain energy (heat, light). When fuels are burned they react with oxygen, which usually comes from the air. This is a chemical reaction called combustion

fuel + oxygen → carbon dioxide + water

We can use the energy produced from burning fuels to do things like cook food, heat water or make things move. The table below gives some information about some commonly used fuels. Which of these fuels is best depends on what we want to use it for. In a car engine, for example, the fuel is burned inside the engine itself, so they need fuels that are gases (or a liquid that when compressed can be easily turned into a gas) and that produce only gases when they are burned. A fuel also needs to be easy to carry quite a lot around on a vehicle so that it can travel a long way without re-fueling. It must also be easy to re-fuel.

Fuel	Solid, Liquid or Gas (at 20°C)	Combustion products	How the fuel is stored	Cost	Energy/gram (kilojoules)
Coal	Solid	Gases & ash	In a heap	Low	33
Diesel	Liquid	Gases	In a tank	Low	46
Ethanol	Liquid	Gases	In a tank	Moderate	30
Hydrogen	Gas	Gas	In cylinders at very high pressure or as a liquid at -253°C	Low	56
Methane (Natural Gas)	Gas	Gases	In cylinders at very high pressure	High	48
Petrol	Liquid	Gases	In tanks	Low	50
Propane (LPG)	Gas	Gases	In cylinders as a liquid (under constant pressure)	Low	16
Wood	Solid	Gases & Ash	In a heap	Very low	30

1. How does the energy transferred by burning 1g of hydrogen compare with the energy transferred by burning 1g of petrol?

____

2. How does the energy transferred by burning 1g of coal compare with the energy transferred by burning 1g of wood?

____

3. Which two fuels are most appropriate for vehicle engines? Give your reasons.

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____

4. Which other fuel could be used? Give your reasons?

____

____

5. Which fuel is most appropriate for rockets? (Rockets are expensive to build and it is important to keep their mass as low as possible). Explain your reasons.

____

____

6. Why is natural gas a popular fuel for heating and cooking in homes?

____

____

7. What other factors, besides those shown in the table, do you think are important when choosing a fuel?

____

____

____

Investigation: Measuring the Energy content of Fuels

When a fuel burns the energy changes are as follow:

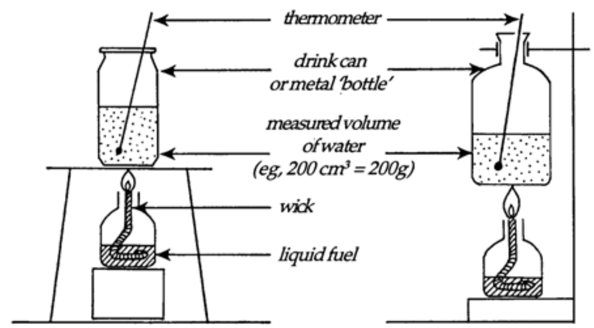
_________________ energy → _____________energy and _____________ energy.

Alcohols not only make good drink additives but are also useful fuels. Both methanol and ethanol have been used as substitutes for petrol. In this experiment, the energy released by burning alcohol is used to heat water. Knowing that 4.18 J of energy is required to heat 1 g (1mL) of water by 1ºC, the quantity of energy released by combustion of the alcohol can be calculated.

Part One : *Which fuel gives the largest temperature rise when 1g of fuel is burnt?*

EQUIPMENT:

alcohol burners: ethanol (C_2H_5OH) and propanol (C_3H_7OH)
thermometer
250ml measuring cylinder
steel can
retort stand and clamp
bench mat
electronic balance



Method:

1. Use a measuring cylinder to pour 200ml of water into a tin can.
2. Use a thermometer to record the temperature of the water.
3. Collect an ethanol burner and use an electronic balance to record the mass of the burner + fuel.
4. Place the burner under the can so that it sits 2-3cm above the wick. Use the retort stand and clamp to secure it in place and then light it.
5. Stir the water gently with the thermometer to assist in even heating and check the temperature every 30 seconds or so.
6. When the temperature of the water has increased by about 20°C extinguish the burner flame.
7. Continue to stir the water until the temperature stops rising. Record the highest temperature.
8. Measure the mass of the burner and the remaining fuel.
9. Repeat with the fuel propanol.

Results and Calculations	Ethanol	Propanol
Mass of burner + fuel at START		
Mass of burner + fuel at END		
Mass of fuel burned overall (g)		
Temperature of water at END		
Temperature of water at START		
Rise in temperature of water (ºC)		
Rise in temperature per gram (ºC/g)		

Question: Which fuel gives the largest temperature rise when 1 gram of fuel is burned?

____

Part Two : ***How much energy is transferred when the fuel is burnt?***

In part one you compared the energy released when burning 1 gram of different fuels by comparing the rise in temperature of the same amount of water.

Scientists know that it take *4.18J of energy to raise the temperature of 1 gram of water by 1°C*. You can use this to measure the actual amount of energy transferred to the water when fuel is burned.

1ml of water = 1g.

Energy in fuel = 4.18 x volume of water x temperature rise/gram
(J) (J) (ml) (°C)

Example calculation:

Burning 1 gram of Fuel X raised the temperature of water by 29°C.

There was 200ml (150g) of water in the can.

Therefore the energy transferred to the water by burning 1g of Fuel X is:

4.18J x 200ml x 29°C = 24244 joules (J) = 24.24kJ

TASK: In the space below, calculate the amount of energy transferred to the water for each gram of the fuels you burned. Show your calculations and results below:

Conclusion:

____

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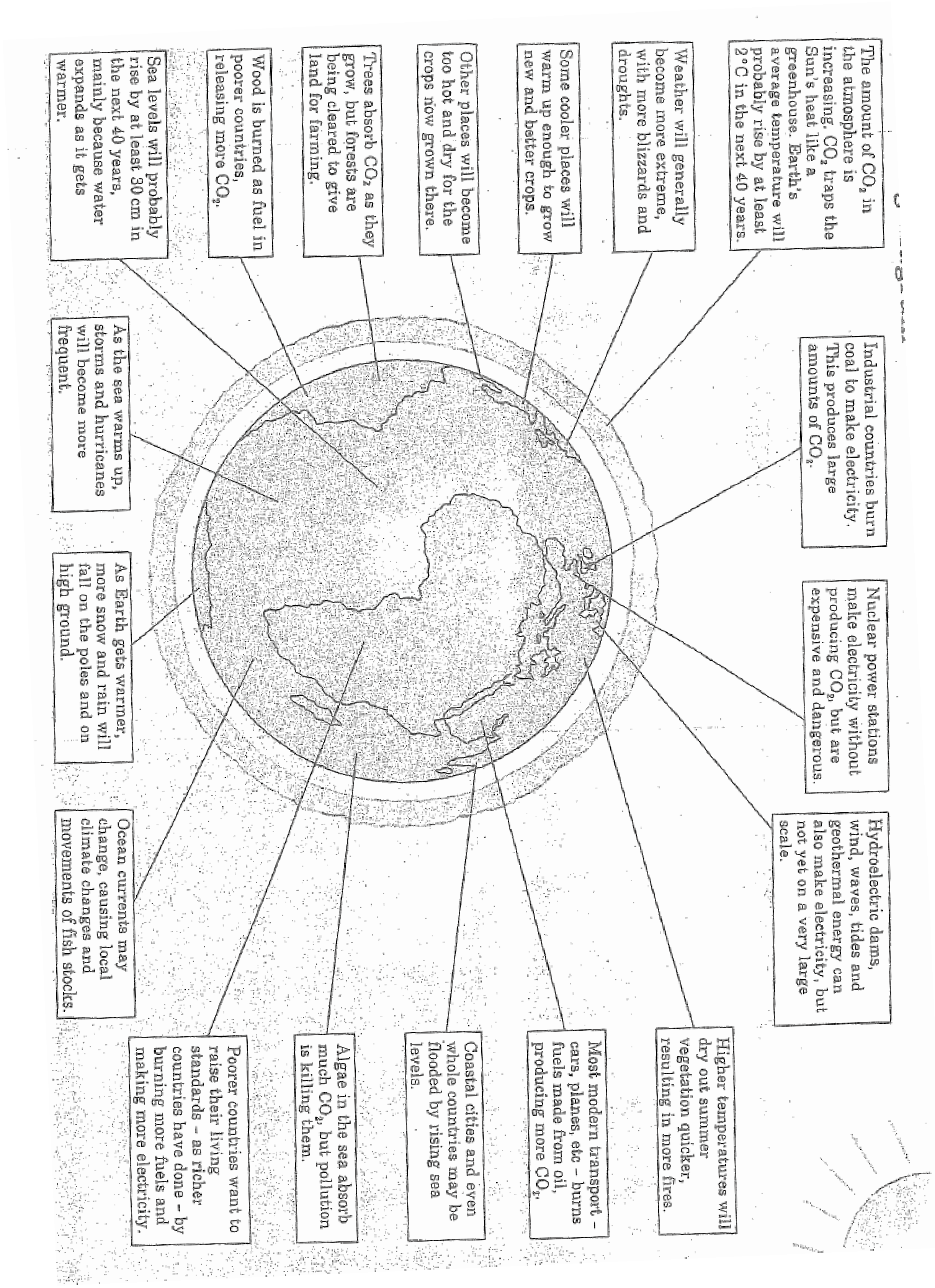
Climate Change

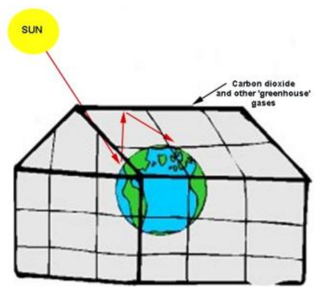
Learning Objective: Explain how greenhouse gases (carbon dioxide, methane, nitrous oxide) can lead to climate change. Describe the processes of carbon dioxide sequestration and understand this as a method to slow down the increase of atmospheric carbon dioxide.



For the temperature of Earth to remain stable:

The heat entering the Earth' atmosphere needs to be the same as the heat that is lost.

The Sun's radiation absorbed by the Earth = Heat radiated back into space.



The Greenhouse Effect

1. The Sun's **infrared radiation** (you can think of this as heat) warms up the Earth.
2. Earths **radiates** heat back, especially at the Polar ice caps, clouds and white buildings (white objects)
3. Larger molecules in the atmosphere (e.g. carbon dioxide, methane, nitrous oxide and water) are flexible and can absorb this infrared radiation that they then emit in all directions, some back down to the Earth.
4. These molecules effectively act like a blanket, warming our Earth.

The basic idea of Earth's 'energy budget' is simple. A constant surface temperature means that the energy coming in is equal to the energy going out. It's important to realize that the greenhouse effect doesn't change this fact.

- If the amount of greenhouse gases *stays the same*, the temperature will remain constant. This will just be a higher temperature than if the greenhouse gases were not there. The energy coming in is still equal to the energy going out.
- If the amount of greenhouse gases *increases*, the temperature will increase. This is because the energy coming in is *greater* than the energy going out. And this is due to the heat-trapping power of the added greenhouse gases.

So simply having greenhouse gases in the atmosphere doesn't cause warming. Adding greenhouse gases to the atmosphere causes warming.

Carbon Sequestration.

Carbon sequestration is the process of capturing and storing carbon dioxide in the atmosphere. It is also the process of capturing CO_2 from new and existing powerplants and factories before they are released into the atmosphere. Once the CO_2 gas has been contained it is placed into long-term storage.

Carbon sequestration is a way to reduce greenhouse gas emissions. It complements two other major approaches for greenhouse gas reduction, namely improving energy efficiency and increasing use of non-carbon energy sources. All three approaches will need to make significant contributions to meet the objective of the United Nations Framework Convention on Climate Change, that is the stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous human interference with the climate system

There are two primary types of carbon sequestration:

1. Carbon dioxide capture and storage, where carbon dioxide is captured at its source (e.g., power plants, industrial processes) and subsequently stored somewhere other than the atmosphere (e.g. depleted oil and gas reservoirs, un-mineable coal seams, deep saline formations, deep ocean). 2. The other type of carbon sequestration focuses on enhancing natural processes to increase the removal of carbon from the atmosphere (e.g. reforestation).

Name some greenhouse gases.

List the 5 different methods of carbon sequestration

Explain: using diagrams if you wish, how the greenhouse effect keeps Earth's surface warmer than it would be if there were no greenhouse gases in the atmosphere.

Briefly describe how the following serve to remove and store carbon dioxide from the atmosphere:
1. Plant Sequestration 2. Ocean sequestration 3. Geosequestration.

Extension: Discuss some of the drawbacks of carbon sequestration.

True or False Statements?

1. Complete combustion of fossil fuels produces water, carbon dioxide and heat energy.
2. The heat energy released in combustion of fossil fuels is responsible for climate change.
3. Driving cars has no effect on climate change.
4. Cutting down rainforests causes climate change.
5. Hydroelectricity causes climate change.
6. Gas is cleaner than coal so burning it instead reduces climate change.
7. Individually we are not responsible for climate change.
8. All fossil fuels contain hydrocarbons, and so contribute to climate change when burnt?
9. The Earth’s temperature has always been the same until humans started to change it?
10. Climate change will mean it will be hot and sunny in most places.

Alternative Fuels

Learning Objective: Describe some of the advantages and disadvantages of biofuels as an alternative to crude oil. Describe the advantages and disadvantages of using hydrogen gas as a fuel.

What are biofuels?
Biofuels are liquid or gaseous fuels made from plant or animal material, for example:
plant oils or sugary/starchy parts of crops, trees, wood chippings and straw, waste oil such as vegetable cooking oil, animal waste, oils in algae

Biofuels are renewable – the plant and animal material from which they are made can be replenished.

Why consider biofuels?
At the moment a lot of the world's energy comes from fossil fuels: coal, oil and gas. These fuels once they have been used cannot be replaced. Fossil fuels are non-renewable energy sources. Some people hope that in the future, biofuels could be used instead of fossil fuels to run cars, trains and even planes. Some of the most popular biofuels are biodiesel made from plant oils of palm or soybean, and bioethanol made from the sugar/starch of corn or sugar cane. The crops from which they are produced are already well-established in agriculture around the world and can be grown quickly.

Where are most biofuels produced?
Most of the biofuels currently used come from crops grown by farmers. Brazil produces a lot of sugar cane, and a large amount of palm oil comes from palm plantations in South-East Asia. European weather is good for growing rapeseed, wheat and sugar beet, while the US grows more corn and soybean.
New types of biofuels, for example those made from algae or non-food crops, are being developed, but commercial production is still some years away.

Why are biofuels popular?
Scientists and governments are worried about climate change, rising oil prices and making sure that they have enough fuels to keep their countries working. They are also trying to find new ways to create jobs and businesses. Because of this, they are desperately searching for alternative fuels.

What is a Biofuel and why are they important?

Most of our fuel is obtained from crude oil or by using natural gas or coal. However this is not sustainable and burning these fuels releases greenhouse gases. Biofuel is a renewable fuel produced from biomass (living things). Scientists are working towards making it carbon neutral.

Two examples of biofuel are bioethanol and biodiesel.

Production of Bioethanol

Sugar beet or sugar cane

Production of Ethanol

1. Fermentation with yeast.

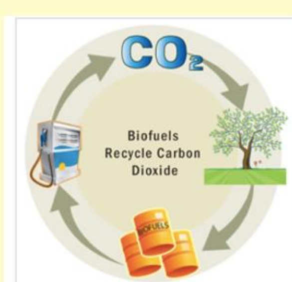
$$\text{Sugar (glucose)} \xrightarrow{\text{yeast}} \text{ethanol + carbon dioxide}$$
$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$$

2. Hydration of ethene.

$$\text{Ethene + steam} \xrightarrow{\text{Catalyst}} \text{ethanol}$$
$$\_\_\_\_ + H_2O \longrightarrow \_\_\_\_\_\_\_\_$$

Carbon Neutral

- Biofuels are carbon neutral, which means that they release only as much carbon dioxide when they burn as was used to make the original oil by photosynthesis.



But are Biofuels really Carbon Neutral?

- Energy is needed to grow the plants.
- To make the fertilizer, transport to harvest and transport the crop
- Energy is needed to turn the plant into a fuel that can be used in vehicles.

Melbourne Biogas – converting sewage into energy

Sewage is much more than a waste product. We can generate electricity by burning biogas, which is captured under covers that are placed over sewage treatment lagoons.

The Western Treatment Plant uses biogas to meet nearly all its electricity needs. It generates 71,500 megawatt hours of renewable electricity every year, which prevents 87,000 tons of carbon dioxide from being emitted through the burning of fossil fuels. Sometimes the plant produces more energy than it uses, so this excess electricity is exported to the electricity grid to offset usage at our other sites.

The Eastern Treatment Plant uses biogas to power a substantial part of its electricity usage, and most of its heating and cooling. The plant's seven generators can run solely on biogas or be supplemented by natural gas as needed.

Plant lights up ... with the mighty power of poo

IF YOU are given lemons, the saying goes, make lemonade. But what can you do with 400 million litres of raw sewage? As it turns out, plenty.

Brad McLean, business improvement manager at Werribee's Western Treatment Plant, says it is all a matter of perspective - disposing of human waste is not a problem but an opportunity. ''It's saying 'we have sewage, it's a resource. How do we make best use of that resource?','' he said.

The answer came in the form of electricity. Western Treatment Plant is being powered - for want of a better word - by poo.

In the early 1990s, hoping to reduce the number of odour complaints from nearby residents, the plant installed covers on its main sewage lagoon. They were very effective and also captured a large amount of biogas, Mr McLean said. So they took ''the gas'' to the market.

Werribee sewage farm, which produces power from biogas.

'The reality is we're good at sewage treatment and we needed a partner who was good at power generation,'' he said. By 1998, the plant had signed a contract with energy company AGL to harness the gas and produce electricity for the site.

''When we first set up we were probably producing around 10 per cent and then as we upgraded the treatment processes, added more components to it and brought more flow through the covered lagoons, we then increased our gas production,'' Mr McLean said.

The plant - which treats roughly half of Melbourne's sewage - now generates 95 per cent of its power from sewage biogas. ''We typically generate 7-8 megawatts of electricity,'' Mr McLean said, adding it was equivalent to powering 15,000 houses ''We can broadly balance out what we consume and what we generate.''

Western Treatment Plant workers install new covers that will capture biogas and generate electricity from raw sewage

In 2014 they replaced old covers and expanded the scale of the operation.

John Myers, the manager of design and development, said that the 100,000 square metres of raw sewage had become a covered biogas farm.

''The cover is about 450 metres long by about 220 metres wide - the equivalent of four MCGs,'' he said.

The high-density polyethylene covers were built in 11 compartmentalised segments, so individual sections could be taken offline for maintenance or cleaning without affecting power generation or odour control. They will have a lifespan of 20 years.

Beyond the biogas success story, the plant is well-known as one of the most popular bird-watching sites in Victoria, and it is listed as a protected wetland, home to a range of endangered flora and fauna. It also produces 40 billion litres of recycled water each year.

For these reasons and more, Mr Myers says he's proud to work at WTP. It's surprising how giving raw sewage can be. "One of our workers a few days ago found a $50 note in one of the lagoons," he said, "so there's some fringe benefits at times for the guys working on the job, if they're prepared to do it."

Biofuels Questions

1. Explain why bioethanol is a renewable fuel.

____

____

2. Write down the word equation and balanced equation, to show what occurs when ethanol burns in a vehicle. Add state symbols to the balanced equation.

Word equation:

____

Balanced Chemical Equation:

____

3. Why could the manufacture and combustion of bioethanol be seen as bring carbon neutral?

____

____

4. Overall, it isn't carbon neutral. Suggest why.

____

____

____

4. a) Highlight the following in different colours.

- What is a biofuel - Advantages of biofuels -Disadvantages of biofuels

Biofuels are made from plant and animal products	Biodiesel is less harmful to animals and plants than diesel	Large amounts of farm land will be used for biofuels instead of food	The waste products of biofuel can be fed to animals
There will be less land available for animals(farms)	Biodiesel is made from oils extracted from plants	Famines could result in poorer countries	Biodiesel burns more cleanly
Ethanol is an example of a biofuel	Biofuel freezes at a lower temperature than diesel	Biogas is made from animal waste	Forests will be clear to grow biofuels
Plants use carbon dioxide to photosynthesis	The biodiesel becomes sticky at high temperatures	Cars which run on biodiesel produce less carbon dioxide	Biofuels will become more important as crude oil runs out
Crude oil will run out	Biodiesel makes very little sulphur dioxide when it burns	Crops used to make biofuels absorb carbon dioxide as they grow. This means that when they are burnt the amount of carbon dioxide will be balanced	Biodiesel turns to sludge at low temperatures

Biofuel

Advantage	**Disadvantages**

The Australian Government legislation defines an ethanol blended fuel as containing more than 1% ethanol, but limits the amount of ethanol in petrol to 10%.

Research:
An 'E' petrol contains ethanol. E10 means that the petrol is mixed with 10% of ethanol. Find out the advantages of having ethanol in petrol.

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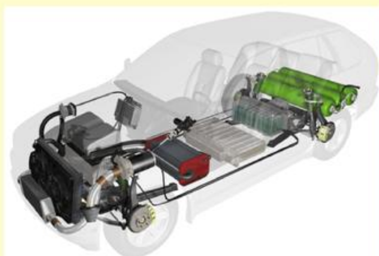
Hydrogen as a Fuel

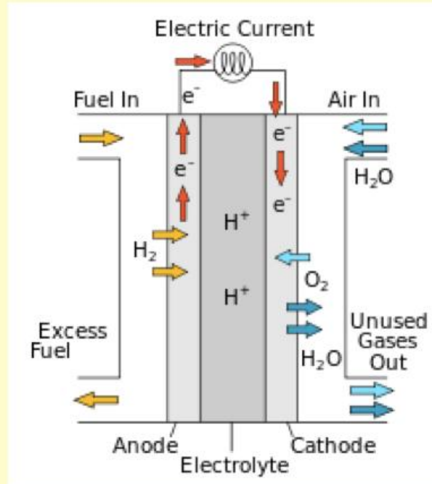
Using Hydrogen as a Fuel

A **fuel cell** uses hydrogen:

It combines **hydrogen** and oxygen to produce electricity, heat, and water. **Fuel cells** are often compared to batteries. Both convert the **energy** produced by a chemical reaction into usable electric power.

hydrogen gas + ______________ → ______________





Questions

A 'hydrogen economy' is one that uses hydrogen as its major form of storing energy for moveable devices, such as cars. Each card A – J represents a fact or opinion about the hydrogen economy.

1. Write an "O" or "F" in each box to show which statements are facts and which are opinions.

2. Highlight, using 2 different colours (red/green) – those statements that are in favour of using hydrogen and those that are against it.

3. Add one or two of your own opinions to the blank cards if you like!

A Hydrogen produces only water when it burns or when it is used in a fuel cell	F Every filling station in the country will need new tanks and pumps for hydrogen
B Hydrogen can explode when it is mixed with oxygen in the air and ignited	G Hydrogen is more dangerous than petrol or diesel because you cannot smell or see leaks – will there have to be more safety checks?
C Hydrogen can be extracted using electricity – and electricity can be generated using renewable energy	H No more exhaust fumes – just steam.

D Most of the hydrogen used in the world today is made from natural gas This process uses energy and releases carbon dioxide	I Electric cars using fuel cells waste more energy overall than electric cars that use normal batteries charged up from the mains We should invest in new battery technology instead
E It will be more difficult and more expensive to transport hydrogen around because it is a gas at normal temperatures	J The government would have to produce a whole new set of safety regulations to make sure everything was done properly!

4. Hydrogen can be burned to release energy, or it can be used in a fuel cell. Tick the boxes in the table to show which statements apply to fuel cells and which ones apply to burning. Some statements can have more than one tick.

Statement	Fuel cell	Burning
Needs oxygen as well as hydrogen		
Produces water		
Produces heat and light		
Produces electricity		
Used in some cars and buses		
Used in rockets		

5. a) Write down one advantage of using hydrogen as a fuel for cars.

____

b) Write down one disadvantage.

____

6. a) What C is a solid fuel?________________________________

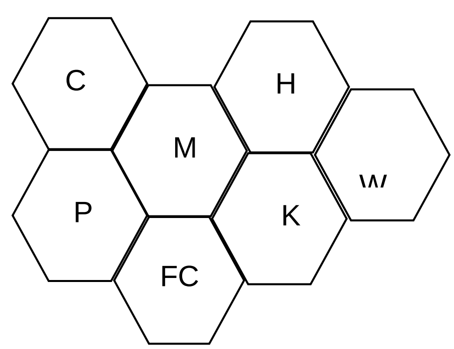
b) What H can be used in rockets?____________________________

c) What M is found in natural gas?____________________________

d) What W produces a lot of ash (carbon) when it burns?___________

e) What P and K are obtained from crude oil?___________________

f) What FC uses hydrogen to make electricity?__________________



7. Write down the names of:

a) three fuels that can be sent through pipes

____

b) two fuels that must be stored under pressure

____

c) a fuel that must be shovelled.

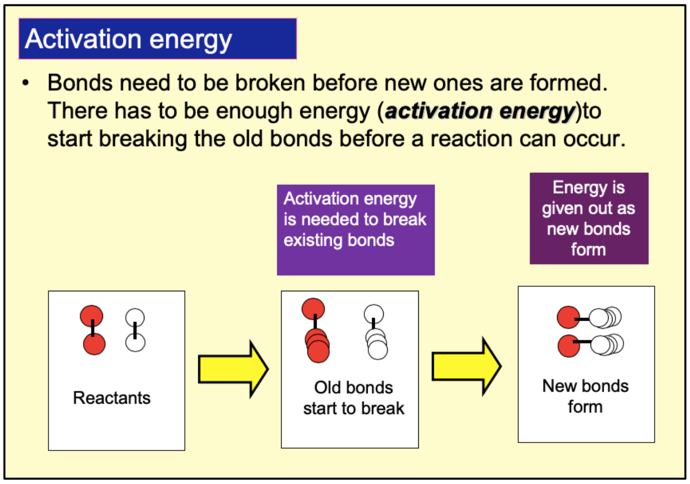
____

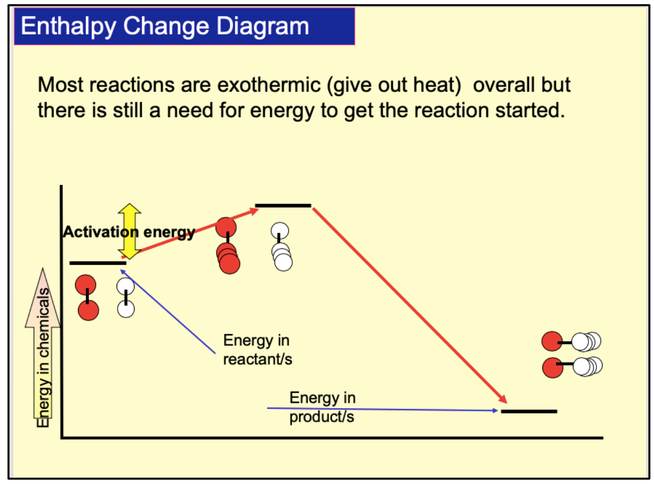
Hydrogen as A Fuel

Advantages	**Disadvantage**

Energy Changes in Reactions (EXT)

Learning Objective:
Draw and interpret simple graphical representations of energy changes occurring in chemical reactions.
Calculate the energy change during a chemical reaction, such as combustion.





In the space below, draw and label an enthalpy diagram below to show an endothermic reaction:

Read the information sheet (“*Exothermic and Endothermic Reactions” on ACGS*) and then answer the following questions

1. What type of energy is stored in bonds?

____

2. This energy stored is the result of 5 different things. What are they?

____

____

3. Explain the difference between the terms 'system' and 'surroundings?

____

____

4. Explain the term enthalpy change ($\triangle$H), how is it calculated?

____

____

5. Compare the enthalpy change in exothermic and endothermic reactions.

____

____

6. Write down the thermochemical equation for respiration.

____

Energy Changes - EXT

Bond energy is defined as the amount of energy required to break a bond. These values are positive, indicating that bond breaking is endothermic. Bond energies are reported in kilojoules per mole (kJ/mol). The energy for breaking a hydrogen-hydrogen bond is 436 kJ/mol so when a hydrogen-hydrogen bond is formed the process releases 436 kJ/mol.

In a chemical reaction several bonds are broken and formed. For example in the reaction below a hydrogen-hydrogen bond is broken and a fluorine-fluorine bond is broken. Two hydrogen-fluorine bonds are formed. The overall energy change for this process is calculated below.

H−H
Bond energy: 436 kJ/mol

F−F
Bond Energy: 155 kJ/mol

H−F
Bond Energy: 567 kJ/mol

example $H_2\,(g) + F_2\,(g) \rightarrow 2HF$

ΔH_{rxn} = [energy used for breaking bonds] – [energy formed in making bonds]

[436 kJ/mol + 155 kJ/mol] – [2(567 kJ/mol)]

= – 543 kJ/mol

EXT

1. $H_2(g) + F_2(g) \rightarrow 2\,HF(g)$ $\Delta H =$ ____________

2. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O\,(g)$ $\Delta H =$ ____________

3. $CO(g) + 2H_2(g) \rightarrow CH_3OH(l)$ $\Delta H =$ ____________

4. $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$ $\Delta H =$ ____________

5. $2H_2O(g) \rightarrow 2H_2(g) + O_2(g)$ $\Delta H =$ ____________

6. $H_2CCH_2(g) + Cl_2(g) \rightarrow ClH_2CCH_2Cl(g)$ $\Delta H =$ ____________

7. $CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g)$ $\Delta H =$ ____________

8. $CH_3COOH + CH_3OH \rightarrow CH_3COOCH_3 + H_2O$ $\Delta H =$ ____________

EXT

KEY QUESTIONS

1 Explain what a negative ΔH value indicates about a chemical reaction, in terms of the relative enthalpies of the reactants and products.

2 When 1 mole of methane gas undergoes combustion in oxygen to produce carbon dioxide and water, 890 kJ of energy is released. Write a balanced thermochemical equation for this reaction.

3 The combustion of octane to form carbon dioxide and liquid water can be written as:

$$C_8H_{18}(g) + 12\tfrac{1}{2}O_2(g) \rightarrow 8CO_2(g) + 9H_2O(l) \quad \Delta H = -5450 \text{ kJ mol}^{-1}$$

The combustion of octane to form carbon dioxide and steam can be written as:

$$C_8H_{18}(g) + 12\tfrac{1}{2}O_2(g) \rightarrow 8CO_2(g) + 9H_2O(g)$$

How would the energy released by the combustion of 1 mole of octane to form steam compare with the energy released by 1 mole of octane to form liquid water?

4 The energy profile diagram in Figure 2.2.7 shows the energy changes during the reaction of hydrogen and iodine to form hydrogen iodide:

$$H_2(g) + I_2(g) \rightarrow 2HI(g)$$

a Is the reaction exothermic or endothermic?

b Describe the relative enthalpies of the reactants and products.

c Comment on the size of the activation energy compared with ΔH.

5 The reaction for photosynthesis is the opposite to the reaction for respiration shown on page 41. Write a thermochemical equation for photosynthesis.

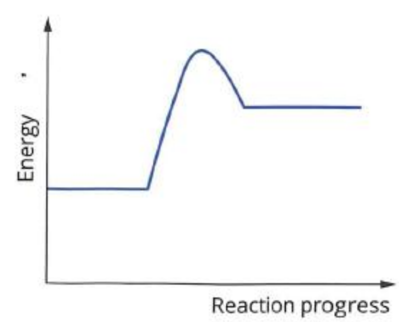


FIGURE 2.2.7 Energy profile of the reaction between hydrogen and iodine to form hydrogen iodide.

EXT Challenge **Ships and Spacecraft**

Some vehicles, such as ships and spacecraft, have people living in them. These vehicles need a source of electricity for heating, lighting and cooking, and for working navigation and other electronic equipment on board. There are different ways of producing this electricity.

- Ships use generators that are powered by their main engines. Most ships use diesel or a heavier fraction of crude oil as a fuel for their engines. Some fast warships use gas turbine engines, similar to the ones used in jet aeroplanes.
- Nuclear submarines can stay under the water for months at a time. The length of a journey is limited only by the amount of food for the crew that can be carried. A nuclear reactor provides energy to move the submarine and is also used to drive generators to produce electricity.
- The Space Shuttle normally stays in orbit for between 7 and 10 days. It uses hydrogen fuel cells to generate the electricity it needs.

1. Before diesel engines were invented, ships used sails or were powered by coal-fired steam engines.

   a) Explain why diesel is a much more convenient fuel than coal to use in ships.

   ____

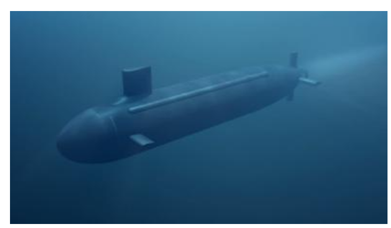
   ____

   b) Explain why a diesel-powered ship needs to carry a smaller mass of fuel than a coal-fired ship.

   ____

   ____

2. Suggest why all submarines that need to stay underwater for several months are nuclear powered, rather than using diesel as a fuel.



   ____

   ____

3. Diesel-powered submarines can only run their engines when they are on the surface. When they are under water, they have to use batteries to power their engines. Suggest why diesel submarines don't just produce oxygen using electrolysis of water to allow their engines to run when they are submerged.

   ____

   ____

4. Why does the Space Shuttle use fuel cells rather than the type of generators in a nuclear submarine?

____

____

5 Write a word equation and a balanced equation for the reaction that happens in a hydrogen/oxygen fuel cell.

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6. The International Space Station (ISS) has been in space for many years. The ISS does not use fuel cells to produce electricity.

   a) Why doesn't it need to? ____

   b) Why does the ISS need batteries?____

   c) Suggest why the Space Shuttle does not use the same method of electricity generation as the ISS?

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More Practice Energy Changes EXT

Determine the energy changes for the following reactions:

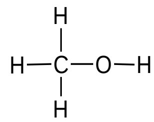
1. Nitrogen + Hydrogen $\rightarrow$ Ammonia

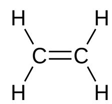
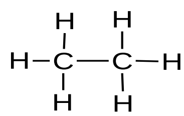
2. $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

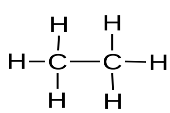
3. $C_2H_4(g) + F_2(g) \rightarrow C_2H_4F_2(g)$

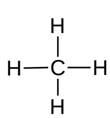
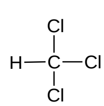
4. methane + oxygen $\rightarrow$ carbon dioxide + water

5. Hydrogen peroxide $\rightarrow$ water + oxygen

6. CΞO + 2 H-H → 

7. H-H +  → 

8.  + 7 O=O → 4 O=C=O + 6 H-O-H

9.  + 3 Cl-Cl →  + 3 H-Cl

10. H-C≡N + H-H →