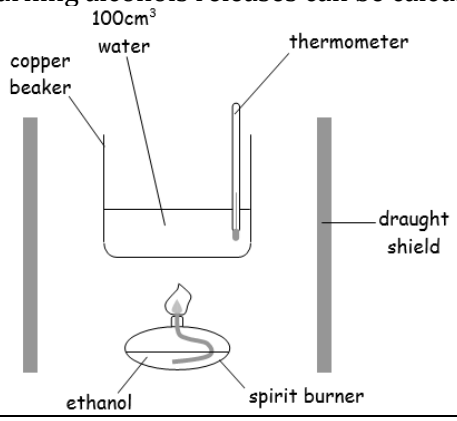
National 5 Chemistry
Unit 2.3 Energy From Fuels

		Lesson	Traffic Light		
			Red	Amber	Green
35	A reaction or process that releases heat energy is described as exothermic. A reaction or process that takes in heat energy is described as endothermic. Reactions with energy changes can raise or lower the temperature of the surroundings: • **Exothermic** reactions release energy to the surroundings (raising the temperature) • **Endothermic** reactions take in energy from the surroundings (lowering the temperature)		☹	😐	☺
36	In combustion, a substance reacts with oxygen releasing energy.		☹	😐	☺
37	Hydrocarbons and alcohols burn completely in a plentiful supply of oxygen to produce carbon dioxide and water. Equations can be written for the complete combustion of hydrocarbons and alcohols: methane + oxygen → carbon dioxide + water $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ ethene + oxygen → carbon dioxide + water $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$ cyclobutane + oxygen → carbon dioxide + water $C_4H_8 + 6O_2 \rightarrow 4CO_2 + 4H_2O$ ethanol + oxygen → carbon dioxide + water $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$		☹	😐	☺
38	Fuels burn releasing different quantities of energy.		☹	😐	☺
39a	The quantity of heat energy burning alcohols releases can be calculated experimentally using:  		☹	😐	☺
39b	The quantity of heat energy released can be calculated using the equation $E_h = cm\Delta T$ $E_h = c \times m \times \Delta T$ Heat Energy (kJ) = Specific Heat Capacity (kJ kg^{-1} °C^{-1}) × Mass (kg) × Change in temperature (°C)				
40	The quantities E_h, c, m or ΔT can be calculated, in the correct units, given relevant data. The enthalpy changes can be calculated using $E_h = c \times m \times \Delta T$. e.g. Calculate the energy released by burning ethanol heated up 200cm³ of water by 6°C. $E_h = c \times m \times \Delta T$ $= 4.18 \times 0.2 \times 6$ $= 5.016$ kJ c = specific heat capacity = 4.18 kJ kg^{-1} °C^{-1} m = mass of water being heated up (worked out by converting volume of water into mass) (NB 1000cm³ water = 1kg of water) e.g. Burning an alcohol released 13.3kJ of energy as it raised the temperature of sodium chloride solution from 15°C to 49°C. The mass of the sodium chloride solution was 100g. Calculate the specific heat capacity of this solution of sodium chloride solution. $E_h = c \times m \times \Delta T \quad \therefore c = \frac{E_h}{m \times \Delta T} = \frac{13.3 \text{ kJ}}{0.1\text{kg} \times 34^\circ\text{C}} = \frac{13.3}{3.4} = 3.91$ kJ kg^{-1} °C^{-1} • Calculations can involve heating substances other than water and the value of c will change to reflect the specific heat capacity of the new substance heating up.		☹	😐	☺

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Past Paper Question Bank
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Outcome	Original Specimen Paper	New Specimen Paper	Nat5 2014	Nat5 2015	Nat5 2016	Nat5 2017	Nat5 2018	Nat5 2019	Nat5 2020	Nat5 2021						
35		L9a	mc14	L6c	L3a	mc14		L9a								
36	mc10	mc10														
37		L8d			mc9	mc12	L16b									
38	L9a L9c(i)				L9b(i)											
39a							mc15	L9b(ii)								
39b																
40	L9b(i)	L9b(i)	L9c	L8b	L9c	L14b	L9b	L9b(i)								

<table>
<tr><th>Nat5</th><th>Answer</th><th>% Correct</th><th>Reasoning</th></tr>
<tr><td>2014
MC
14</td><td>C</td><td>47</td><td>☒A energy being required to start a reaction does indicate either exo/endothermic
☒B heat being given off indicates an exothermic reaction
☑C A temperature drop during a reaction indicates an endothermic reaction
☒D A temperature rise during a reaction indicates an exothermic reaction</td></tr>
<tr><td>2016
MC
9</td><td>B</td><td>63</td><td>☒A carbon (soot) is formed by incomplete combustion in a limited supply of air
☑B carbon dioxide & water formed by complete combustion in plentiful supply of air
☒C carbon monoxide is formed by incomplete combustion in a limited supply of air
☒D hydrogen is formed by incomplete combustion in a limited supply of air</td></tr>
<tr><td>2017
MC
12</td><td>C</td><td>50</td><td><table><tr><td>Element in Fuel</td><td>Carbon</td><td>Hydrogen</td><td>Sulphur</td></tr><tr><td>Product of Combustion</td><td>Carbon Dioxide</td><td>Water</td><td>Sulphur Dioxide</td></tr></table></td></tr>
<tr><td>2017
MC
14</td><td>B</td><td>92</td><td>☒A Endothermic reactions absorb energy from the surroundings (drops the temp)
☑B exothermic reactions release energy to the surroundings (raises the temp)
☒C Energy required to start reaction not related to the energy given off
☒D A reaction must have an energy change to be exothermic</td></tr>
<tr><td>2018
MC
15</td><td>B</td><td>-</td><td>☒A metal beaker used instead of glass beaker to allow heat to conduct better
☑B metal beaker and draught shield should be used for the most accurate result
☒C draught shield should be used to reduce heat loss
☒D draught shield should be used to reduce heat loss</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

Nat5	Answer	Reasoning
2014 9c	3135	E_h = c × m × ΔT Energy = specific heat capacity × mass × change in temperature Energy = 4.18 × 25 × 30 Energy = 3135kJ
2015 6c	exothermic	Exothermic: Chemical reaction which gives out energy Endothermic: Chemical reaction which takes in energy from the surroundings
2015 8b	14.2 kJ	E_h = c × m × ΔT Energy = specific heat capacity × mass × change in temperature E_h = 4.18 × 0.1 × 34 E_h = 14.212kJ
2016 3a	Exothermic	Exothermic: Chemical reaction where heat energy is released to surroundings (temperature of the surroundings increases) Endothermic: Chemical reaction where heat energy is absorbed from surroundings (temperature of the surroundings decreases)
2016 9b(i)	-OH on end increases the energy released	The energy released is consistently higher when –OH group in on 1st/end carbon (-1-ol alcohol) than it is when the –OH is on the 2nd carbon (-2-ol)
2016 9c	55.0	$E_h = cm\Delta T \therefore \Delta T = \frac{E_h}{c \times m} = \frac{23}{(4.18 \times 0.1)} = 55.0^oC$
2017 14b	3.91	$E_h = cm\Delta T \therefore c = \frac{E_h}{m \times \Delta T} = \frac{13.3}{(0.1 \times 34)} = 3.91\ kJ\ kg^{-1}\ ^oC^{-1}$
2018 9b	472.8	heat energy = specific heat capacity × mass × change in Temperature E_h = c × m × ΔT E_h = 1.97 kJ kg^{-1} $^oC^{-1}$ × 1.5kg × 20^oC E_h = 472.8 kJ
2018 16b	Any answer from:	Sulphur oxide | Sulphur monoxide | Sulphur dioxide | Sulphur trioxide
2019 9a	Exothermic	Exothermic: Reaction which releases energy Endothermic: Reaction which takes in energy from the surroundings
2019 9b(i)	0.05	heat energy = specific heat capacity × mass × change in Temperature E_h = C × m × ΔT 8.36 = 4.18 × m × 40 $m = \frac{8.36}{4.18 \times 40} = 0.05kg$
2019 9b(ii)	Both answers:	Copper is a better conductor of heat Lower heat loss to surroundings

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Outcome	Int2 2000	Int2 2001	Int2 2002	Int2 2003	Int2 2004	Int2 2005	Int2 2006	Int2 2007	Int2 2008	Int2 2009	Int2 2010	Int2 2011	Int2 2012	Int2 2013	Int2 2014	Int2 2015
35	mc4			L2a		L3a(ii)	L12a			L3a	L2a			mc1	L5a	
36				L2c		mc9						mc9				
37		mc12 L2a		L10a	L13b				mc8		mc10		mc11	mc11	mc12	
38	L11a									L6a						L4a
39a																
39b																
40															L8c	

Int2	Answer	% Correct	Reasoning
2000 MC 4	D	42	☒A In exothermic reactions, heat is released to the surroundings ☒B In exothermic reactions, heat is released to the surroundings ☒C If products have more chemical energy than the reactants, heat must be taken in (endo) ☑D If products have less chemical energy than the reactants, heat must be taken in (exo)
2001 MC 12	C	45	<table><tr><td>Product</td><td>Carbon dioxide</td><td>Sulphur Dioxide</td><td>Water</td></tr><tr><td>Element in Reactant</td><td>carbon</td><td>sulphur</td><td>hydrogen</td></tr></table>
2005 MC 9	A	35	☑A Combustion: burning reaction joining up with oxygen ☒B Condensation: small molecules join together with water removed at join ☒C Dehydration: water is removed from a molecule leaving a C=C double bond ☒D Hydrolysis: larger molecule breaks up with water added at the split
2008 MC 8	D	65	Hydrocarbons burn in a plentiful supply of air to form carbon dioxide and water • Methane is an alkane • alkanes are hydrocarbons
2010 MC 10	A	70	☑A $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$ ☒B $C_2H_6 + 3\frac{1}{2}O_2 \rightarrow 2CO_2 + 3H_2O$ ☒C $C_4H_8 + 6O_2 \rightarrow 4CO_2 + 4H_2O$ ☒D $C_4H_{10} + 6\frac{1}{2}O_2 \rightarrow 4CO_2 + 5H_2O$
2011 MC 9	A	41	☑A Combustion is the burning a substance in oxygen ☒B Condensation joins together two molecules removing water at the join point ☒C Dehydration removes water from a molecule leaving a C=C double bond behind ☒D Hydrolysis is breaking down a larger compound adding water across the break
2012 MC 11	B	68	☒A $C_2H_6 + 3\frac{1}{2}O_2 \rightarrow 2CO_2 + 3H_2O$ ∴1 mole of C_2H_6 burns to form 2 moles of CO_2 ☑B $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$ ∴1 mole of C_3H_8 burns to form 3 moles of CO_2 ☒C $C_4H_{10} + 6\frac{1}{2}O_2 \rightarrow 4CO_2 + 5H_2O$ ∴1 mole of C_4H_{10} burns to form 4 moles of CO_2 ☒D $C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$ ∴1 mole of C_5H_{12} burns to form 5 moles of CO_2
2013 MC 1	B	93	☒A energy is released in any exothermic reaction to the surroundings ☑B energy is released in any exothermic reaction to the surroundings ☒C energy absorbed from the surroundings is an endothermic reaction ☒D when the products have more energy than the reactants then energy has been absorbed from the surroundings during the reaction ∴ endothermic reaction
2013 MC 11	C	46	☒A if compound burned produces H_2O then hydrogen must be found in the fuel ☒B if compound burned produces CO_2 then carbon must be found in the fuel ☑C If CO_2 and H_2O are found in the products then fuel contains both C and H ☒D oxygen could either be found in the fuel or the air the fuel burned in
2014 MC 12	C	45	☒A nitrogen compound formed comes from nitrogen in compound being burned ☒B hydrogen compound formed comes from hydrogen in compound being burned ☑C compounds of nitrogen, hydrogen and carbon formed mean all three must be in compound being burned ☒D oxygen could have come from the air that the compound was burned in

<table>
<tr><th>Int2</th><th>Answer</th><th>Reasoning</th></tr>
<tr><td>2000
11a</td><td>Substance which burns to give out energy</td><td>A fuels is any substance which burns to give out energy e.g. heat energy</td></tr>
<tr><td>2001
2a</td><td>Carbon dioxide and water</td><td>Alkynes are hydrocarbons. Hydrocarbons burn in a plentiful supply of air to produce carbon dioxide and water.</td></tr>
<tr><td>2003
2a</td><td>Reaction which releases heat/energy</td><td>Exothermic: reactions which give out energy or heat
Endothermic: reactions which absorb energy/heat from the surroundings</td></tr>
<tr><td>2003
2c</td><td>Jar A has more oxygen (33%) than air</td><td>When dinitrogen monoxide breaks down, it contains 67% nitrogen and 33% oxygen. As air has 21% oxygen, candle will burn longer in 33% oxygen.</td></tr>
<tr><td>2003
10a</td><td>carbon dioxide and water</td><td>Methane is a hydrocarbon. Hydrocarbons burn to form carbon dioxide and water. The remaining 30% carbon dioxide does not burn.</td></tr>
<tr><td>2004
13b</td><td>Carbon, nitrogen and hydrogen</td><td><table><tr><th>Product</th><th>Elements present that must be TNT</th></tr><tr><td>Carbon dioxide</td><td>Carbon (only)</td></tr><tr><td>Nitrogen</td><td>Nitrogen</td></tr><tr><td>water</td><td>Hydrogen (only)</td></tr></table></td></tr>
<tr><td>2005
3a(ii)</td><td>exothermic</td><td>Exothermic: reactions which release (heat) energy
Endothermic: reactions which absorb heat energy from the surroundings</td></tr>
<tr><td>2006
12a</td><td>exothermic</td><td>Exothermic reactions: reaction which gives out (heat) energy
Endothermic reaction: reaction which takes in heat from the surroundings</td></tr>
<tr><td>2009
3a</td><td>exothermic</td><td>Exothermic Reactions: Heat energy given out
Endothermic Reaction: Energy absorbed from the surroundings</td></tr>
<tr><td>2009
6a</td><td>A substance which burns to give out energy</td><td>Fuels are burned for the purpose of releasing energy which can then be used for a purpose.</td></tr>
<tr><td>2010
2a</td><td>Endothermic</td><td><table><tr><td>Exothermic</td><td>Reaction which gives off energy/heat to the surroundings</td></tr><tr><td>Endothermic</td><td>Reaction which takes in energy/heat from the surroundings</td></tr></table></td></tr>
<tr><td>2014
5a</td><td>Exothermic</td><td><table><tr><th>Type</th><th>Description</th><th>ΔH sign</th></tr><tr><td>Exothermic</td><td>Reaction which gives off heat/energy to surroundings</td><td>negative</td></tr><tr><td>Endothermic</td><td>Reaction which absorbs heat/energy from the surroundings</td><td>positive</td></tr></table></td></tr>
<tr><td>2014
8c</td><td>3.344</td><td>$E_h = c \times m \times \Delta T$
Energy = specific heat capacity × mass × change in temperature
Energy = 4.18 × 0.1 × 8
Energy = 3.344kJ</td></tr>
<tr><td>2015
4a</td><td>(A substance which) burns to produce energy</td><td>A fuel is a substance which burns to produce energy.
Oxygen gas is required for any substance to burn</td></tr>
</table>

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Past Paper Question Bank
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Outcome	2000 Credit	2001 Credit	2002 Credit	2003 Credit	2004 Credit	2005 Credit	2006 Credit	2007 Credit	2008 Credit	2009 Credit	2010 Credit	2011 Credit	2012 Credit	2013 Credit		
35							16c									
36 37											20b					
38				10a												
39a																
39b																
40																

SG Credit	Answer	Reasoning
2003C **10a**	Chemical which burns to give out energy	Fuels release energy (heat or kinetic) when burned
2006C **16c**	Water may freeze	Freezing point of pure water is 0°C
2010C **20b**	carbon dioxide & water	Alkanols burn to in a plentiful supply of air to form carbon dioxide and water: $2C_3H_7OH + 9O_2 \longrightarrow 6CO_2 + 8H_2O$

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Outcome	2000 General	2001 General	2002 General	2003 General	2004 General	2005 General	2006 General	2007 General	2008 General	2009 General	2010 General	2011 General	2012 General	2013 General		
35						9b				9a				17c		
36 37	12a 12b			16c		17a		9b(i)	19d					11d		
38					9a				19c							
39a																
39b																
40																

SG General	Answer	Reasoning
2000G 12a	oxygen	All substances use up oxygen as they burn.
2000G 12b	carbon dioxide water	Candle wax is a hydrocarbon ∴ candle wax only contains carbon and hydrogen • carbon burns to form carbon dioxide (turns lime water milky) • hydrogen burns to form water (condenses in test tube A)
2003G 16c	water or H_2O	$2H_2 + O_2 \longrightarrow H_2O$
2004G 9a	burns to release energy	A fuel is a substance which releases energy (usually heat) when it is burned.
2005G 9b	exothermic	Exothermic: a reaction which releases heat Endothermic: a reaction which takes in heat
2005G 17a	carbon dioxide and water	Carbon in $C_2H_6O_2$ burns to form CO_2, hydrogen in $C_2H_6O_2$ burns to form H_2O: ethylene glycol + oxygen ⟶ carbon dioxide + water $2C_2H_6O_2 + 5O_2 \longrightarrow 4CO_2 + 6H_2O$
2007G 9b(i)	oxygen	All combustion/burning reactions require oxygen as a reactant
2008G 19c	substance burned to give out energy	Fuels are burned to release energy (usually heat energy)
2008G 19d	carbon dioxide + water	Hydrocarbons: compounds containing hydrogen and carbon only • hydrogen burns to form water (H_2O) • carbon burns to form carbon dioxide (CO_2) in plentiful supply of air
2009G 9a	exothermic	Exothermic: Reaction which gives out heat Endothermic: Reaction which takes in heat from the surroundings
2013G 11d	Carbon dioxide and water	Methane is a hydrocarbon with the formula CH_4. • the carbon in methane burns in a plentiful supply of air to form carbon dioxide. • the hydrogen in methane burns to form water.
2013G 17c	Gives out heat	Exothermic: Reaction which gives out heat Endothermic: Reaction which takes in heat from the surroundings