HOME PRACTICE 4.7

1. The enthalpy of combustion of ethanol can be measured by heating water with an ethanol spirit burner.

(a) List the measurements needed in this experiment and say how each is obtained. **(3)**

(b) What assumption is made in this experiment? **(1)**

(c) In what way can the experimental design be improved in light of this assumption? **(1)**

2. In an experiment, 0.16 g of methanol, CH_3OH (RFM = 32), is used up when a spirit burner heats 100 g of water from 17 °C to 25 °C.

(Specific heat capacity of water is 4.18 $kJ\,kg^{-1}\,°C^{-1}$.)

(a) Write an equation for the enthalpy of combustion of methanol. **(1)**

(b) Use the results above to calculate the enthalpy change for the mass of methanol burned in the experiment. **(2)**

(c) From the enthalpy change in the experiment, calculate the enthalpy of combustion of methanol. **(2)**

TOTAL **(10)**

Mark your answers by using the Answer Check.

CHALLENGE CHEMISTRY

– Higher –

SECTION 4

MOLE & ENERGY

HOME PRACTICE

The "Home Practice" problems are for doing at home. They follow exactly the lesson topics of the section.

It is good practice to look again at a lesson topic just a short time afterwards, for example – the evening of the same day.

The "Home Practice" problems are designed to help you do that. As each lesson topic is covered in school, then the corresponding "Home Practice" should be done within two days at home.

By doing this consistently, you help to build yourself a memory bridge for the future.

HOME PRACTICE 4.1

1. State the value and units of the Avogadro constant. (1)

2. What is constant about one mole of any substance? (1)

3. Calculate the number of molecules in 9.1 moles of any molecular substance. (2)

4. Calculate the number of molecules in 27 g of water. (3)

5. Calculate the amount in moles of sodium chloride which contains 1.6×10^{21} ions.

   (Hint: You will need to consider how many ions there are in the formula unit for sodium chloride.) (3)

TOTAL (10)

Mark your answers by using the Answer Check.

HOME PRACTICE 4.6

1. Define the term 'enthalpy of neutralisation'. (1)

2. Why is the enthalpy of neutralisation always $-57\ kJ\ mol^{-1}$ and not dependent on the acid being neutralised? (1)

3. Write the equation for the enthalpy of neutralisation when sodium hydroxide and phosphoric acid, H_3PO_4, react. (1)

4. In an experiment, 4.8 g of solid ammonium chloride (RFM = 53.5) was dissolved in $100\ cm^3$ of water. A temperature drop of 3.5 °C was recorded.

   (Specific heat capacity of water is $4.18\ kJ\ kg^{-1}\ °C^{-1}$ and the density of water is $1\ g\ cm^{-3}$)

   (a) Calculate the enthalpy change which took place in the experiment. (2)

   (b) Calculate the enthalpy of solution for ammonium chloride from these results. (2)

6. Calculate the enthalpy of combustion of butane, C_4H_{10}, if the enthalpy change for 2.9 g of butane being completely burned is –143.85 kJ. (3)

TOTAL (10)

Mark your answers by using the Answer Check.

HOME PRACTICE 4.5

1. What is meant by an **exothermic** reaction? **(1)**

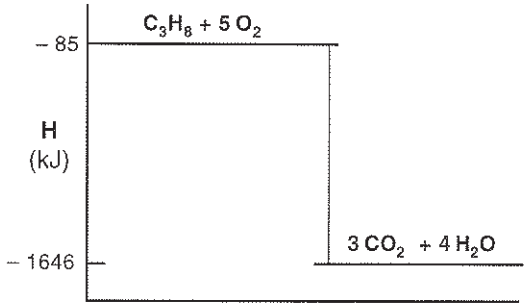
2. Define the term 'enthalpy' and give its symbol and units. **(2)**

3. What is meant by an **endothermic** reaction? **(1)**

4. Reactions are normally accompanied by an enthalpy change.
   (a) Define the term 'enthalpy change' in words. **(1)**
   (b) Give the expression for enthalpy change using symbols. **(1)**

5. Calculate the enthalpy change for the combustion of propane using the diagram below. Include the sign and units.

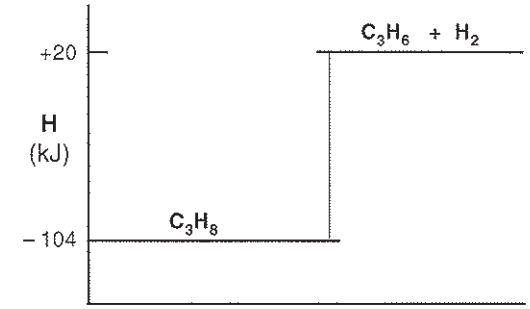
Combustion of propane



(2)

6. Calculate the enthalpy change for the cracking of propane using the diagram below. Include the sign and units.

Cracking of propane



(2)

TOTAL **(10)**

Mark your answers by using the Answer Check.

HOME PRACTICE 4.2

1. Calculate the molar volume of carbon dioxide, CO_2 (RFM = 44), if 88 g has a volume of 48.84 litres. **(2)**

2. Find the amount in moles of 400 cm^3 of argon when the molar volume is 24.03 $l\,mol^{-1}$. **(2)**

3. What is the mass of 125 cm^3 of carbon monoxide gas, CO, when the molar volume is 24.01 $l\,mol^{-1}$? **(3)**

4. What volume of hydrogen gas, H_2, contains 10^{23} atoms when the molar volume is 24.08 $l\,mol^{-1}$? **(3)**

TOTAL **(10)**

Mark your answers by using the Answer Check.

HOME PRACTICE 4.3

1. Which reactant is in excess if 2.5 g of calcium carbonate is reacted with 200 cm^3 of 0.1M hydrochloric acid (i.e. 0.1 mol l^{-1})?

   The equation for the reaction is shown below.

   $$CaCO_3 + 2\,HCl \rightarrow CaCl_2 + H_2O + CO_2$$

   Show all your working. **(5)**

2. Magnesium nitrate can be prepared by reacting magnesium with very dilute nitric acid.

   $$Mg + 2\,HNO_3 \rightarrow Mg(NO_3)_2 + H_2$$

   Find the limiting reactant when 2.1 g of magnesium is reacted with 250 cm^3 of 0.2 M nitric acid (i.e. 0.2 mol l^{-1}).

   Show all your working. **(5)**

TOTAL **(10)**

Mark your answers by using the Answer Check.

HOME PRACTICE 4.4

1. What volume of pentane must be burned in excess oxygen to produce 100 cm^3 of carbon dioxide when the product gas has been cooled to the starting temperature?

   $$C_5H_{12}(g) + 8\,O_2(g) \rightarrow 5\,CO_2(g) + 6\,H_2O(l)$$ **(2)**

2. Which reactant gas is in excess and by how much when 30 cm^3 of butane is burned in 250 cm^3 of oxygen?

   $$2\,C_4H_{10}(g) + 13\,O_2(g) \rightarrow 8\,CO_2(g) + 10\,H_2O(l)$$ **(4)**

3. In an experiment, 300 cm^3 of ethene gas is completely burned in 1000 cm^3 of oxygen.

   $$C_2H_4(g) + 3\,O_2(g) \rightarrow 2\,CO_2(g) + 2\,H_2O(l)$$

   What will the total gas volume be when the reaction is complete and the remaining substances allowed to return to room temperature? **(4)**

TOTAL **(10)**

Mark your answers by using the Answer Check.

H HOME PRACTICE DATA SHEET H

Element	Symbol	Valency	RAM
aluminium	Al	3	27.0
argon	Ar	0	40.0
bromine	Br	1	79.9
calcium	Ca	2	40.0
carbon	C	4	12.0
chlorine	Cl	1	35.5
copper	Cu	2	63.5
fluorine	F	1	19.0
gold	Au	1 or 3	197.0
helium	He	0	4.0
hydrogen	H	1	1.0
iodine	I	1	126.9
iron	Fe	2 or 3	55.8
lead	Pb	2 or 4	207.2
lithium	Li	1	6.9

Element	Symbol	Valency	RAM
magnesium	Mg	2	24.3
mercury	Hg	2	200.6
neon	Ne	0	20.2
nickel	Ni	2	58.7
nitrogen	N	3	14.0
oxygen	O	2	16.0
phosphorus	P	3	31.0
platinum	Pt	2 or 4	195.1
potassium	K	1	39.1
silicon	Si	4	28.1
silver	Ag	1	107.9
sodium	Na	1	23.0
sulphur	S	2	32.1
tin	Sn	2 or 4	118.7
zinc	Zn	2	65.4

Formulae and valencies of groups containing more than one kind of atom

Valency 1		Valency 2		Valency 3	
Group	Formula	Group	Formula	Group	Formula
ammonium	NH_4	carbonate	CO_3	phosphate	PO_4
ethanoate	CH_3COO	chromate	CrO_4		
hydroxide	OH	dichromate	Cr_2O_7		
nitrate	NO_3	sulphate	SO_4		
permanganate	MnO_4	sulphite	SO_3		

H HOME PRACTICE DATA SHEET H

Element	Symbol	Valency	RAM
aluminium	Al	3	27.0
argon	Ar	0	40.0
bromine	Br	1	79.9
calcium	Ca	2	40.0
carbon	C	4	12.0
chlorine	Cl	1	35.5
copper	Cu	2	63.5
fluorine	F	1	19.0
gold	Au	1 or 3	197.0
helium	He	0	4.0
hydrogen	H	1	1.0
iodine	I	1	126.9
iron	Fe	2 or 3	55.8
lead	Pb	2 or 4	207.2
lithium	Li	1	6.9

Element	Symbol	Valency	RAM
magnesium	Mg	2	24.3
mercury	Hg	2	200.6
neon	Ne	0	20.2
nickel	Ni	2	58.7
nitrogen	N	3	14.0
oxygen	O	2	16.0
phosphorus	P	3	31.0
platinum	Pt	2 or 4	195.1
potassium	K	1	39.1
silicon	Si	4	28.1
silver	Ag	1	107.9
sodium	Na	1	23.0
sulphur	S	2	32.1
tin	Sn	2 or 4	118.7
zinc	Zn	2	65.4

Formulae and valencies of groups containing more than one kind of atom

Valency 1		Valency 2		Valency 3	
Group	Formula	Group	Formula	Group	Formula
ammonium	NH_4	carbonate	CO_3	phosphate	PO_4
ethanoate	CH_3COO	chromate	CrO_4		
hydroxide	OH	dichromate	Cr_2O_7		
nitrate	NO_3	sulphate	SO_4		
permanganate	MnO_4	sulphite	SO_3		

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ANSWER CHECK 4.7

1. **(a)** Mass of ethanol burned (½), by weighing burner with ethanol before and after combustion (½)

Mass of water being heated (½), by measuring the volume used (since 1 cm^3 has a mass of 1 g) (½)

Temperature change of water (½), by measuring temperature of water before and after combustion (½) **(3)**

(b) All the heat from the flame is transferred to the water. **(1)**

(c) Enclose the apparatus to reduce heat loss to surroundings.
OR Use a very thin metal beaker. **(1)**

2. **(a)** $CH_3OH(l) + \frac{3}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$ **(1)**

(b) $\Delta H = -cm\Delta T$ (½)

$= -4.18\ kJ\,kg^{-1}\,°C^{-1} \times 0.1\ kg \times 8\ °C$ (½)

$= -3.344\ kJ$ **(1)** **(2)**

(c) Find: x kJ from 32 g [i.e. 1 mol] (½)

Link: -3.344 kJ ⟷ 0.16 g

Proportion: $\frac{x\ kJ}{-3.344\ kJ} = \frac{32\ g}{0.16\ g}$ (½)

So $x = \frac{32 \times (-3.344)}{0.16} = -669$

So ΔH_c is $-669\ kJ\,mol^{-1}$ **(1)** **(2)**

TOTAL **(10)**

Learn from any mistakes by checking over all wrong answers.
Ask your teacher about anything you still do not understand.

CHALLENGE CHEMISTRY

– Higher –

SECTION 4

MOLE & ENERGY

ANSWER CHECK

FOR HOME PRACTICE QUESTIONS

Checking your answers is an important part of the learning process.

You should check out every mistake, even if it is just one mark.

If you still do not understand a question, even after studying this answer check, then ask your teacher.

ANSWER CHECK 4.1

1. $6.02 \times 10^{23}\,\text{mol}\,l^{-1}$ [Value (½), units (½)] **(1)**

2. They contain 6.02×10^{23} formula units. **(1)**

3. [Using the 'find-from' method]

Find:	x molecules	from	9.1 mol	
Link:	6.02×10^{23} f.u.	↔	1 mol	(½)
Convert:	6.02×10^{23} molecules		1 mole	
Proportion:	$\frac{x \text{ molecules}}{6.02 \times 10^{23} \text{ molecules}} = \frac{9.1 \text{ mol}}{1 \text{ mol}}$			(½)

So $x = \frac{9.1 \times 6.02 \times 10^{23}}{1} = 5.48 \times 10^{24}$ molecules **(1)** **(2)**

4. H_2O

$1 \times 16 = 16$

$2 \times 1 = 2$

RFM = 18 (½)

Find:	x molecules	from	27 g water	
Link:	6.02×10^{23} f.u.	↔	18 g	(½)
Proportion:	$\frac{x \text{ molecules}}{6.02 \times 10^{23} \text{ molecules}} = \frac{27 \text{ g}}{18 \text{ g}}$			(½)

So $x = \frac{27 \times 6.02 \times 10^{23}}{18} = 9.03 \times 10^{23}$ molecules **(1)** **(3)**

5.

Find:	x mol NaCl	from	1.6×10^{21} ions	
Link:	1 mol	↔	6.02×10^{23} f.u.	(½)
Convert:			12.06×10^{23} **ions**	**(1)**
Proportion:	$\frac{x \text{ mol}}{1 \text{ mol}} = \frac{1.6 \times 10^{21} \text{ ions}}{12.06 \times 10^{23} \text{ ions}}$			(½)

So $x = \frac{1.6 \times 10^{21} \times 1}{12.06 \times 10^{23}} = 1.3 \times 10^{-3}$ mol **(1)** **(3)**

TOTAL **(10)**

Learn from any mistakes by checking over all wrong answers.
Ask your teacher about anything you still do not understand.

ANSWER CHECK 4.6

1. It is the enthalpy change per mole of water formed when an acid is neutralised by an alkali. **(1)**

2. It is always the same reaction. (½)

$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$ (½) **(1)**

3. $\frac{1}{3}H_3PO_4(aq) + NaOH(aq) \rightarrow \frac{1}{3}Na_3PO_4(aq) + H_2O(l)$ **(1)**

4. **(a)** $\Delta H = -c\,m\,\Delta T$ (½)

$= -4.18 \times 0.1 \times (-3.5)$ (½)

$= +1.46$ kJ **(1)** **(2)**

(b)

Find:	x kJ	from	53.5 g [i.e. 1 mol]	(½)
Link:	+1.46 kJ	↔	4.8 g	
Proportion:	$\frac{x \text{ kJ}}{+1.46 \text{ kJ}} = \frac{53.5 \text{ g}}{4.8 \text{ g}}$			(½)

So $x = \frac{53.5 \times 1.46}{4.8} = 16.3$

So ΔH_{soln} is $+16.3\,\text{kJ}\,\text{mol}^{-1}$ **(1)** **(2)**

5. C_4H_{10}

$10 \times 1 = 10$

$4 \times 12 = 48$

RFM = 58 (½)

Find:	x kJ	from	58 g [i.e. 1 mol]	(½)
Link:	−143.85 kJ	↔	2.9 g	
Proportion:	$\frac{x \text{ kJ}}{-143.85 \text{ kJ}} = \frac{58 \text{ g}}{2.9 \text{ g}}$			(½)

So $x = \frac{58 \times (-143.85)}{2.9} = -2877$

So ΔH_c is $-2877\,\text{kJ}\,\text{mol}^{-1}$ **(1)** **(3)**

TOTAL **(10)**

Learn from any mistakes by checking over all wrong answers.
Ask your teacher about anything you still do not understand.

ANSWER CHECK 4.5

1. A chemical change which gives out heat **(1)**

2. Stored chemical energy **(1)**

Symbol: **H** (½)

Units: kilojoules **OR** kJ (½) **(2)**

3. A chemical change which takes in heat **(1)**

4. (a) The difference between the final total enthalpy of the products and the original total enthalpy of the reactants **(1)**

(b) $\Delta H = H_{(products)} - H_{(reactants)}$ **(1)**

5. $\Delta H = H_{(products)} - H_{(reactants)}$ (½)

$= (-1646) - (-85)$ (½)

$= -1561$ kJ **(1)**

[**Negative** sign, value and unit all required] **(2)**

6. $\Delta H = H_{(products)} - H_{(reactants)}$ (½)

$= (+20) - (-104)$ (½)

$= +124$ kJ **(1)**

[**Positive** sign, value and unit all required] **(2)**

TOTAL **(10)**

Learn from any mistakes by checking over all wrong answers.
Ask your teacher about anything you still do not understand.

ANSWER CHECK 4.2

1. 88 g = 2 mol **(1)**

So molar volume $= \frac{48.84}{2} = 24.42\ l\,mol^{-1}$ **(1)** **(2)**

2. Find: x mol from 0.4 l

Link: 1 mol ↔ 24.03 l (½)

Proportion: $\frac{x \text{ mol}}{1 \text{ mol}} = \frac{0.4\ l}{24.03\ l}$ (½)

So $x = \frac{0.4 \times 1}{24.03} = 0.017$ mol **(1)** **(2)**

3. CO

1 x 16 = 16
1 x 12 = 12
RFM = 28 (½) (½)

Find: x g CO from 125 cm^3

Link: 1 mol ↔ 24.01 l (½)

Convert: 28 g 24010 cm^3

Proportion: $\frac{x\ g}{28\ g} = \frac{125\ cm^3}{24010\ cm^3}$ (½)

So $x = \frac{125 \times 28}{24010} = 0.146$ g **(1)** **(3)**

4. Find: $x\ l$ from 1.0×10^{23} atoms

Link: 24.08 l ↔ 1 mol H_2 (½)

Convert: 6.02×10^{23} molecules

$= 1.204 \times 10^{24}$ atoms **(1)**

Proportion: $\frac{x\ l}{24.08\ l} = \frac{1.0 \times 10^{23} \text{ atoms}}{1.204 \times 10^{24} \text{ atoms}}$ (½)

So $x = \frac{24.08 \times 1.0 \times 10^{23}}{1.204 \times 10^{24}} = 2\ l$ **(1)** **(3)**

TOTAL **(10)**

Learn from any mistakes by checking over all wrong answers.
Ask your teacher about anything you still do not understand.

ANSWER CHECK 4.3

1. $CaCO_3$ + 2 HCl → $CaCl_2$ + H_2O + CO_2
1 mol 2 mol 1 mol 1 mol 1 mol

Choose $CaCO_3$ and calculate quantity of HCl needed.

$CaCO_3$
3 x 16 = 48
1 x 12 = 12 (½)
1 x 40 = 40
RFM = 100 (½)

Find: x mol HCl from 2.5 g of $CaCO_3$
Link: 2 mol ↔ 1 mol (½)
Convert: 100 g
Proportion: $\frac{x \text{ mol}}{2 \text{ mol}} = \frac{2.5 \text{ g}}{100 \text{ g}}$ (½)

So $x = \frac{2.5 \times 2}{100} = 0.05$ mol HCl **(1)**

Quantity HCl available = $0.2\,l \times 0.1 \text{ mol } l^{-1} = 0.02$ mol **(1)**
$CaCO_3$ is in excess (since not enough HCl available). **(1)** **(5)**

2. Mg + 2 HNO_3 → $Mg(NO_3)_2$ + H_2
1 mol 2 mol 1 mol 1 mol

Choose Mg and calculate quantity of HNO_3 needed.

Find: x mol HNO_3 from 2.1 g of Mg
Link: 2 mol ↔ 1 mol (½)
Convert: 24.3 g **(1)**
Proportion: $\frac{x \text{ mol}}{2 \text{ mol}} = \frac{2.1 \text{ g}}{24.3 \text{ g}}$ (½)

So $x = \frac{2.1 \times 2}{24.3} = 0.17$ mol **(1)**

Quantity HNO_3 available = $0.25\,l \times 0.2 \text{ mol } l^{-1} = 0.05$ mol **(1)**
So HNO_3 is limiting reactant (since not enough available). **(1)** **(5)**

TOTAL **(10)**

Learn from any mistakes by checking over all wrong answers.
Ask your teacher about anything you still do not understand.

ANSWER CHECK 4.4

1. Find: x cm³ C_5H_{12} from 100 cm³ of CO_2
Link: 1 vol ↔ 5 vol (½)
Convert: 1 cm³ 5 cm³
Proportion: $\frac{x \text{ cm}^3}{1 \text{ cm}^3} = \frac{100 \text{ cm}^3}{5 \text{ cm}^3}$ (½)

So $x = \frac{100 \times 1}{5} = 20 \text{ cm}^3 C_5H_{12}$ **(1)** **(2)**

2. [Choosing 30 cm³ C_4H_{10} and finding vol O_2 needed]
Find: x cm³ O_2 from 30 cm³ of C_4H_{10}
Link: 13 vol ↔ 2 vol (½)
Convert: 13 cm³ 2 cm³
Proportion: $\frac{x \text{ cm}^3}{13 \text{ cm}^3} = \frac{30 \text{ cm}^3}{2 \text{ cm}^3}$ (½)

So $x = \frac{30 \times 13}{2} = 195 \text{ cm}^3 O_2$ **(1)**

So excess gas is O_2 (since 250 cm³ available). **(1)**
Excess volume = 250 cm³ – 195 cm³ = 55 cm³ **(1)** **(4)**

3. [Choosing 300 cm³ C_2H_4 and finding vol O_2 needed]
Find: x cm³ O_2 from 300 cm³ of C_4H_{10}
Link: 3 vol ↔ 1 vol (½)
Convert: 3 cm³ 1 cm³
Proportion: $\frac{x \text{ cm}^3}{3 \text{ cm}^3} = \frac{300 \text{ cm}^3}{1 \text{ cm}^3}$ (½)

So $x = \frac{3 \times 300}{1} = 900 \text{ cm}^3 O_2$ **(1)**

Vol O_2 unused = 1000 cm³ – 900 cm³ = 100 cm³ (½)
Vol CO_2 formed = 2 x 300 cm³ = 600 cm³ (½)
So total gas volume after reaction = 700 cm³ **(1)** **(4)**

TOTAL **(10)**

Learn from any mistakes by checking over all wrong answers.
Ask your teacher about anything you still do not understand.