Calorimetry 1

A Level

C C C

Essential Pre-Uni Chemistry F1.1

Specific heat capacity of water $= 4.18\,\mathrm{J\,g^{-1}\,K^{-1}}$.

Part A (a)

Calculate the heat capacity of an object with mass $1.80\,\mathrm{kg}$ and specific heat capacity $0.32\,\mathrm{J\,g^{-1}\,K^{-1}}$.

Part B (b)

Calculate the heat capacity of a calorimeter if its temperature is raised $2.5\,\mathrm{K}$ by $35\,\mathrm{kJ}$ of heat.

Part C (c)

Calculate the expected increase in temperature when $2.4\,\mathrm{kJ}$ of heat is transferred to a calorimeter of heat capacity $720\,\mathrm{J\,K^{-1}}$.

Part D (d)

Calculate the heat required to raise the temperature of a calorimeter of heat capacity $1.6\,\mathrm{kJ\,K^{-1}}$ by $3.8\,^{\circ}\mathrm{C}$.

Part E (e)

Calculate the specific heat capacity of a calorimeter if it has a mass of $375\,\mathrm{g}$ and its temperature is raised $4.2\,\mathrm{K}$ by $2160\,\mathrm{J}$ of heat.

Part F (f)

Calculate the heat required to raise the temperature of $3.14\,\mathrm{kg}$ of water by $12.2\,\mathrm{K}$.

Part G (g)

Calculate the mass of water whose temperature is raised through $16.0\,\mathrm{K}$ by $6.7\,\mathrm{kJ}$ of heat.

Part H (h)

A calorimeter consists of $140\,\mathrm{g}$ of aluminium and $300\,\mathrm{g}$ of water. $6100\,\mathrm{J}$ of heat raises its temperature by $4.42\,\mathrm{K}$. Calculate to three significant figures:

its heat capacity;

the specific heat capacity of aluminium.

Calorimetry 3

A Level

Essential Pre-Uni Chemistry F1.3

Specific heat capacity of water $= 4.18\,\mathrm{J\,g^{-1}\,K^{-1}}$.

The enthalpy change of combustion of naphthalene is $-5156\,\mathrm{kJ\,mol^{-1}}$. Its molar mass is $128.2\,\mathrm{g\,mol^{-1}}$. Calculate the temperature change expected when $1.00\,\mathrm{mmol}$ is burnt in excess oxygen in a calorimeter containing $4.0\,\mathrm{kg}$ of water.

Gameboard:

STEM SMART Chemistry Week 12

Calorimetry 5

A Level

Essential Pre-Uni Chemistry F1.5

Specific heat capacity of water $= 4.18\,\mathrm{J\,g^{-1}\,K^{-1}}$.

Complete combustion of $0.020\,\mathrm{mol}$ of ethane, with a standard enthalpy of combustion of $-1410.8\,\mathrm{kJ\,mol^{-1}}$ raises the temperature of the water in an insulated calorimeter from $17.4\,^{\circ}\mathrm{C}$ to $22.4\,^{\circ}\mathrm{C}$. Calculate the mass of the water in the calorimeter.

Gameboard:

STEM SMART Chemistry Week 12

Calorimetry 7

A Level

Essential Pre-Uni Chemistry F1.7

Specific heat capacity of water $= 4.18\,\mathrm{J\,g^{-1}\,K^{-1}}$.

$25.0\,\mathrm{cm^3}$ of sulfuric acid at $1.00\,\mathrm{mol\,dm^{-3}}$ and $19.10\,^\circ\mathrm{C}$ is placed in an insulated polystyrene cup. When $25.0\,\mathrm{cm^3}$ of sodium hydroxide at $2.00\,\mathrm{mol\,dm^{-3}}$ and $19.10\,^\circ\mathrm{C}$ is added, the temperature rises to $32.45\,^\circ\mathrm{C}$.

Assuming that no heat is lost, that the specific heat capacity of water may be used, and that the solutions have a density of $1.00\,\mathrm{g\,cm^{-3}}$ at $19.10\,^\circ\mathrm{C}$, find the enthalpy change of the reaction per mole of water produced by neutralisation.

Gameboard:

STEM SMART Chemistry Week 12

Calorimetry 8

A Level

Essential Pre-Uni Chemistry F1.8

Specific heat capacity of water $= 4.18\,\mathrm{J\,g^{-1}\,K^{-1}}$

$30.0\,\mathrm{cm^3}$ of ethanoic acid at $1.60\,\mathrm{mol\,dm^{-3}}$ and $18.65\,^{\circ}\mathrm{C}$ is placed in an insulated polystyrene cup. When $40.0\,\mathrm{cm^3}$ of sodium hydroxide at $1.00\,\mathrm{mol\,dm^{-3}}$ and $18.65\,^{\circ}\mathrm{C}$ is added, the temperature rises to $25.80\,^{\circ}\mathrm{C}$.

Assuming that no heat is lost, that the specific heat capacity of water may be used, and that the solutions have a density of $1.00\,\mathrm{g\,cm^{-3}}$ at $18.65\,^{\circ}\mathrm{C}$, find the enthalpy change of the reaction per mole of water produced by neutralisation.

Gameboard:

STEM SMART Chemistry Week 12

Calorimetry 9

A Level

Essential Pre-Uni Chemistry F1.9

Specific heat capacity of water $= 4.18\,\mathrm{J\,g^{-1}\,K^{-1}}$.

When $5.0\,\mathrm{g}$ of ammonium nitrate dissolves in $100\,\mathrm{g}$ of water, the temperature of the water drops from $18\,^{\circ}\mathrm{C}$ to $14\,^{\circ}\mathrm{C}$. Calculate the enthalpy of solution of ammonium nitrate in $\mathrm{kJ\,mol^{-1}}$ using the following scheme.

Part A Formula

Write down the formula of ammonium nitrate.

Part B Relative formula mass

Calculate the relative formula mass of ammonium nitrate. Give your answer to 3 significant figures.

Part C Number of moles

Calculate the number of moles of ammonium nitrate in $5.0\,\mathrm{g}$.

Part D Heat loss of water

Calculate the heat lost from the $100\ \mathrm{g}$ of water. Give your answer to 2 significant figures.

Part E Molar heat loss of ammonium nitrate

Calculate the heat lost per mole of ammonium nitrate.

Part F Enthalpy of ammonium nitrate

Give the enthalpy of solution of ammonium nitrate.

Gameboard:

STEM SMART Chemistry Week 12

Calorimetry 10

A Level

P P P

Essential Pre-Uni Chemistry F1.10

The enthalpies of combustion of three fuels are shown below:

Fuel	ΔH_c / kJ mol^{-1}
CH_4	-890.3
C_3H_8	-2219.2
C_4H_{10}	-2876.5

Part A **(a)**

Which gives out most heat per gram?

Part B **(b)**

Which gives out most heat per mole?

Part C **(c)**

Which gives out most heat per cubic foot?

Average Bond Enthalpy

A Level

The average bond enthalpy of the $\mathrm{C{-}F}$ bond in tetrafluoromethane is given by the standard enthalpy change for one of the following reactions. Which one is it?

- $\frac{1}{4}\,\mathrm{CF_4(g)} \longrightarrow \frac{1}{4}\,\mathrm{C\,(g)} + \mathrm{F\,(g)}$
- $\mathrm{CF_4(g)} \longrightarrow \mathrm{CF_3{}^+\,(g)} + \mathrm{F^-\,(g)}$
- $2\,\mathrm{F_2\,(g)} + \mathrm{C(s)} \longrightarrow \mathrm{CF_4\,(g)}$
- $\mathrm{CF_4(g)} \longrightarrow \mathrm{CF_3\,(g)} + \mathrm{F\,(g)}$
- $\mathrm{CF_4(s)} \longrightarrow \mathrm{CF_4\,(g)}$

Adapted with permission from UCLES, OCSEB A Level Chemistry, June 1995, Paper 1, Question 10

Gameboard:

STEM SMART Chemistry Week 12

Bond Enthalpies 3

GCSE C C C A Level P P P

Essential Pre-Uni Chemistry F2.3

Use some of the following bond enthalpies in $\mathrm{kcal\,mol^{-1}}$ to calculate the enthalpy changes for the reactions (in the gas phase):

$\mathrm{C{=}C}$	146	$\mathrm{C \equiv O}$	258
$\mathrm{O{=}O}$	119	$\mathrm{H{-}O}$	111
$\mathrm{C{-}H}$	99	$\mathrm{H{-}H}$	104
$\mathrm{C{=}O}$	178		

Part A **(a)**

$\mathrm{C_2H_4 + O_2 \longrightarrow 2\,CH_2O}$. Give your answer to 2 significant figures.

Part B **(b)**

$\mathrm{CO + H_2O \longrightarrow CO_2 + H_2}$. Give your answer to 2 significant figures.

Part C **(c)**

$\mathrm{CH_2O \longrightarrow CO + H_2}$. Give your answer to 2 significant figures.

Bond Enthalpies 4

A Level

Essential Pre-Uni Chemistry F2.4

Given that the bond energy of $\mathrm{H-H}$ is $4.53\,\mathrm{eV}$, $\mathrm{D-D}$ is $4.59\,\mathrm{eV}$, and the energy change on reaction $\mathrm{H_2 + D_2 \longrightarrow 2\,HD}$ is $+0.02\,\mathrm{eV}$, find the bond energy of $\mathrm{H-D}$. Give your answer to 3 significant figures.