CALORIMETRY – WORKSHEET 1

QUESTION 1
The table below describes features common to a solution calorimeter and a bomb calorimeter as well as differences.

Features of Both the Solution and Bomb Calorimeters	Features of the Bomb Calorimeter Only
W	Y
X	Z

The letters W, X, Y and Z respectively could represent:

A Insulated vessel, calibration heater, stirring rod, thermometer.
B Calibration heater, stirring rod, thermometer, ignition wire.
C Stirring rod, thermometer, ignition wire, pressurised compartment.
D Thermometer, ignition wire, pressurised compartment, stirring rod.

QUESTION 2
A student connected a solution calorimeter to an electric circuit and supplied $6.00\,V$ and maintained a current of $185\,mA$ for a period of 5.0 minutes. The temperature rose from $19.14^{o}C$ to $19.58^{o}C$. The calibration constant for this calorimeter is

A $12.6\ Jg^{-1}\,{}^{o}C^{-1}$
B $146\ Jg^{-1}\,{}^{o}C^{-1}$
C $757\ Jg^{-1}\,{}^{o}C^{-1}$
D $12.6\ Jg^{-1}\,{}^{o}C^{-1}$

Solution

QUESTION 3
A group of students use a bomb calorimeter to determine the energy content of a biscuit. Which of the following is an example of a random error that could occur during the experiment?

A The students used another group's calibration factor for all their calculations.

B The markings on the thermometer had worn off, so the lab technician had re-labelled it. Unfortunately, this had been done incorrectly.

C The mechanism in the electronic balance was bent, and the reading was always $0.002\ g$ greater than it should have been.

D The stirring rod of the calorimeter was broken, and so the water bath was not stirred throughout the experiment.

QUESTION 4
A student knows that one gram of apple yields about $22.5\ kJ$ of energy. She weighs a small piece of apple and burns it in a bomb calorimeter. The bomb calorimeter contains 100 mL of water and has a calibration factor of $450 J\,^{o}C^{-1}$. The small piece of apple has a mass of $0.12\ g$. She should expect the temperature of the water to rise by approximately:

A $0.17^{o}C$
B $1.2^{o}C$
C $2.4^{o}C$
D $6.0^{o}C$

Solution

QUESTION 5

When barium hydroxide and ammonium cyanate are mixed, the following reaction occurs:

$$Ba(OH)_2.8H_2O_{(s)} + 2NH_4CNO_{(s)} \rightarrow Ba(CNO)_{2(s)} + 2NH_{3(aq)} + 10H_2O_{(l)} \quad \Delta H = 75\, kJ/mol$$

$31.53\ g$ of hydrated barium hydroxide (molar mass $= 315.3\ g/mol$) are mixed with $6.0\ g$ of ammonium cyanate (molar mass $= 60\ g/mol$) in a calorimeter. The calorimeter constant is 150 $J/^oC$. If the initial temperature is $20^o C$, the final temperature will be

A $-30^o C$

B $-5^o C$

C $45^o C$

D $70^o C$

Solution

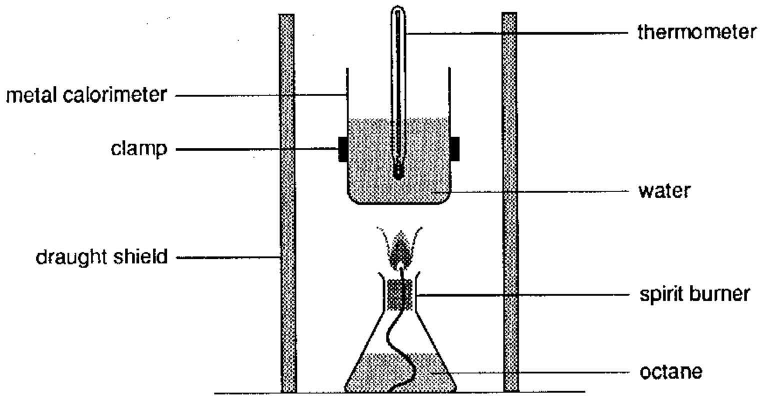
QUESTION 6

A $0.254\ g$ sample of black coal was burnt in a calorimeter. The $300\ ml$ of water in the calorimeter rose in temperature from 18.25 to $24.92^o C$. Calculate the heat of combustion of the coal sample.

Solution

QUESTION 7

A student determined the heat of combustion of octane using the apparatus illustrated. She measured the mass of octane burnt and the rise in temperature of the water in the calorimeter. From this data she calculated the heat of combustion.



Mass of water in calorimeter:	500 g
Initial temperature of the water:	17.0° C
Final temperature of the water:	20.9° C
Initial mass of burner plus octane:	94.7 g
Final mass of burner plus octane:	92.5 g

Specific heat of water is 4.2 J g^{-1} K^{-1}

(a) Write an equation for the complete combustion of one mole of octane.

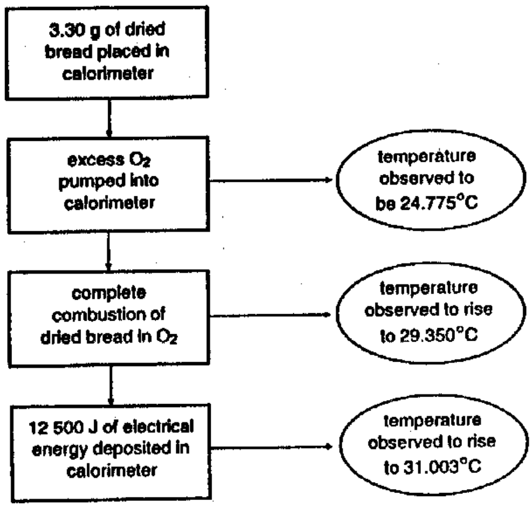
(b) State three ways in which the student could have improved this experiment and obtained a more accurate value for the molar heat of combustion of octane.

(c) How many kilojoules are absorbed in raising the temperature of the water from $17.0^o C$ to $20.9^o C$?

(d) Use these results to calculate the heating energy which would have been evolved if one mole of octane had been burnt.

QUESTION 8

A chemist wishes to determine the heat of combustion of a sample of completely dry bread. He dries a sample of the bread in an oven for 30 minutes, weighs it, carries out the series of operations and measurements shown in the following diagram.



(a) Calculate the calibration factor of the calorimeter plus contents.

(b) Calculate the heat of combustion of the bread in kJ per gram.

(c) It is suggested that the measured heat of combustion may be in error because of the $3.30\ g$ bread sample originally placed in the calorimeter was not completely dry. Suggest a simple way of finding out if a given bread sample was completely dry.

(d) If the $3.30\ g$ bread sample had not been completely dry, what error would this have introduced into the measured heat of combustion? Give a reason for your answer.

(e) Cakes and carrots are both rich in carbohydrates. Why is the carbohydrate in cake observed to be much more fattening than the same mass of carbohydrate in carrot?

(f) A sample of cornflakes was combusted in a bomb calorimeter in order to determine the energy content of food. Would these results give a true indication of the energy content of the food? Would these results give the true indication of energy available to the body? Give a reason for your answer.

QUESTION 9

In an experiment to determine the energy content of naphthlane, $C_{10}H_8$, a bomb calorimeter was used.

Initially a constant current of $1.80\ A$ was passed through the electric heater for 75.00 seconds. The potential difference was $4.95V$. The temperature increased from 18.25^oC to 18.32^oC

A $1.19\,g$ sample of naphthalene was then burnt in the bomb calorimeter and the temperature increased from 18.32^oC to 23.74^oC.

Calculate the heat of combustion for naphthalene.

Solution

SOLUTIONS

QUESTION 1 **Answer is C**

QUESTION 2 **Answer is C**

QUESTION 3 **Answer is D**

QUESTION 4 **Answer is D**

QUESTION 5 **Answer is B**

$n[Ba(OH)_2] = \frac{31.53}{35.3} = 0.1$ $n(NH_4CNO) = \frac{6.0}{60} = 0.1$

$\therefore$ Only 0.05 mol $Ba(OH)_2$ used

$\therefore$ Heat absorbed = $0.05 \times 75 \times 1000 = 3750 J$

$\Delta T = \frac{3750}{150} = 25°C$. Final T = $20 - 25 = -5°C$

Reaction is endothermic
$\therefore$ T decreases

QUESTION 6

Energy (J) = SHC × m × ΔT
= $4.184 \times 300 \times 6.67$
= 8372.184 J
= -8.372 kJ
= -32.95 kJ/g

QUESTION 7

(a) $C_8H_{18}(l) + \frac{25}{2}O_2(g) \rightarrow 8CO_2(g) + 9H_2O(l)$

(b)
- Insulation to minimise heat loss
- Take into account the heat gained by beaker
- include a stirrer
- calibration factor

(c)
$E(J) = m \times SHC \times \Delta T$
$= 500 \times 4.18 \times (20.9 - 17.0)$
$= 8.2 \times 10^3$ J
$= 8.2$ kJ

(d)

mass of octane burnt = 94.7 − 92.5 g
= 2.20 g

Mr (C_8H_{18}) = 114.2 g/mol

$n = \frac{M}{Mr} = \frac{2.20}{114.2} = 0.0193$ mole

1 mole = x

0.0193 mole = 8.2 kJ

x = 4.3×10^2 kJ.

QUESTION 8

(a)

$CF = \frac{12500}{31.003 - 29.350} = 7562\ J/°C$

(b)

$E(J) = CF \times \Delta T = 7562 \times (29.350 - 24.775)$

$= 34596.15\ J / 3.30g$

$= 10483.68\ J/g = 10.48\ kJ/g = 10.5\ kJ/g$

(c)

Weigh sample, heat at > 100°C, Reweigh
If weight changes, sample is NOT dry.

(d)

- ΔH would be lower as some energy evolved would be used to evaporate water.
- As water occupies some of the mass of sample, sample would weigh less if dry ∴ ΔH will be lower.

(e)

Our body is able to derive energy from the carbohydrates in coke, and store excess carbohydrate intake as fat. The carbohydrates in carrots are largely in the form of indigestible materials that cannot be used / stored by the body ∴ less fattening.

(f)

No - as corn contains cellulose, which will release energy when combusted in a calorimeter but cannot be used to derive energy by the human body.

QUESTION 9

$$CF = \frac{VIt}{\Delta T} = \frac{4.95 \times 1.80 \times 75}{18.32 - 18.25} = 9546.43\ J/°C$$

$$E(J) = CF \times \Delta T$$
$$= 9546.43 \times (23.74 - 18.32)$$
$$= 51741.65\ J \text{ per } 1.19g$$

Naphthalene:

$$n = \frac{M}{Mr} = \frac{1.19}{128.164} = 0.00928\ mol$$

0.00928 mol → − 51741.65 J

1 mol → x

$x = -5575608.90\ J$

$$\Delta H = -5.58 \times 10^3\ kJ/mol$$