Bomb Calorimeter Chemistry Questions with Solutions

Q1. The heat measured in a bomb calorimeter for a reaction is:

a.) ΔG
b.) ΔH
c.) ΔU
d.) PΔV

Correct Answer- (c.) ΔU
Explanation- A bomb calorimeter is a constant-volume calorimeter used to calculate the heat of combustion of a specific reaction.

Q2. A bomb calorimeter is used to calculate the heat of reaction at a constant ____.

a.) Volume
b.) Pressure
c.) Temperature
d.) None of the above

Correct Answer- (a.) Volume
Explanation- A bomb calorimeter measures a reaction's change in internal energy, ΔU. This is equal to q_V, the heat of reaction, at constant volume.

Q3. The work done in a bomb calorimeter during the combustion of one mole of CH_4 is:

a.) 490 kJ/mol
b.) 880 kJ/mol
c.) 550 kJ/mol
d.) 660kJ/mol

Correct Answer- (b.) 880 kJ/mol

Q4. What is the most commonly used standard for calibrating bomb calorimeters in teaching laboratories?

a.) Benzoic acid
b.) Acetic acid
c.) Phenol
d.) Picric acid

Correct Answer- (a.) Benzoic acid

Q5. In a bomb calorimeter, CH_4 is burned and then cooled to 27 degrees Celsius.

a.) ΔU = –ve, PΔV = –ve
b.) ΔU = –ve, ΔPV = –ve
c.) ΔU = –ve, PΔV = 0
d.) Both (b) and (c) are correct

Correct Answer- (a.) ΔU = –ve, PΔV = –ve

Q6. At 25℃, the heat of combustion of ethanol measured in a bomb calorimeter is 670.48 KCal mol^{-1}. Calculate the reaction's ΔH at 25℃.

Answer. $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$
ΔH = ΔU + ΔnRT
Since, Δn = 2 – 3 = 1
= –670.48 + (–1) × 2 × 298 Cal
= –670.48 – 0.596 KCal
= –671.08 KCal

Q7. What is the purpose of the bomb calorimeter?

Answer. The Bomb Calorimeter was used to calculate the cross calorific value of the solid and liquid samples. A constant-volume calorimeter measures the heat of a specific reaction or the calorific value of fuels.

Q8. What is the fundamental principle of a bomb calorimeter?

Answer. The bomb calorimeter's basic principle is to measure heat at a constant volume. Since the reaction is a combustion reaction, the heat measured by this apparatus is heat of combustion.

Q9. In which instance would a bomb calorimeter be more useful than a coffee-cup calorimeter?

Answer. Since bomb calorimeters can operate at high pressures, they are especially useful when dealing with gases. When water begins to boil and produces vapour, coffee-cup calorimeters are useless.

Q10. When 1.0 g of fructose, $C_6H_{12}O_6(s)$, a sugar commonly found in fruits, is burned in oxygen in a bomb calorimeter, the temperature of the calorimeter increases by 1.58 °C. If the heat capacity of the calorimeter and its contents is 9.90 kJ/°C, what is the enthalpy for this combustion?

Answer. Heat released by the combustion = C_p × ΔT = 9.90 kJ/°C × 1.58 °C = 15.642 kJ.

Hence, $\Delta H = -15.6$ kJ/g
Molar mass of fructose = 180 g.
Hence, $\Delta H_{combustion} = -15.6 \times 180$ kJ/mol = -2808 kJ/mol

Q11. A 0.88 g gummy bear is burned in a bomb calorimeter. The temperature started at 21.5 °C and leveled off at 24.2 °C. The manufacturer of the bomb calorimeter determined the heat capacity of the calorimeter to be 11.4 kJ/°C. Calculate the heat of combustion per gram of gummy bear.

Answer. $\Delta E = C_V\Delta T$ = (11.4 kJ/°C)(24.2-21.5 °C) = (11.4 kJ/°C)(2.7 °C) = 30.78 kJ
(30.78 kJ)/(0.88 g) = 34.98 kJ/g

Q12. When a 100 g sample of methane, CH_4, is burned in a bomb calorimeter, the temperature changes from 21 °C to 31 °C and 2200 J of heat is given off. What is the specific heat of methane?

Answer.
$\Delta E = C_V\Delta T = C_V = \Delta E/\Delta T$ = (2200 J)/(10 °C) = 220 J/°C
Specific heat = C_V/g = (220 J/°C)/(100 g) = 2.20 J/g – °C

Q13. A sample of 0.562 g of carbon is burned in oxygen in a bomb calorimeter, producing carbon dioxide. Assume both the reactants and products are under standard state conditions and that the heat released is directly proportional to the enthalpy of the combustion of graphite. The temperature of the calorimeter increases from 26.74 °C to 27.93 °C. What is the heat capacity of the calorimeter and its contents?

Answer.
The amount of heat transferred can be calculated by using the formula, $q = mc\Delta T$ (eq. i)
where,
q is the amount of heat transferred,
c is the specific heat,
ΔT is the change in temperature,
m is the mass of the substance.
As in the case of a bomb calorimeter, mass is assumed to be constant, so the equation for the calorimeter mentioned becomes
$q = c\Delta T$ (eq ii)

The standard molar enthalpy of combustion for carbon is -393.5 kJ/mol.
The molecular mass of carbon is 12 grams per mole.

As a result, the number of moles of carbon equivalent to 0.562 grams of carbon can be calculated as follows:
Number of moles of carbon = mass / molecular mas

= 0.562 grams / 12 gram per mole
= 0.047 mol
The heat generated by burning 0.562 grams or 0.047 mole will be,
q = ΔH° × number of moles
= (-393.51 kJ/mol) × 0.047 mol
= -18.49 kJ, the negative sign shows that the heat is produced.

To calculate the heat capacity of a calorimeter, put q = -18.49 kJ and T = (27.93 °C - 26.74 °C) in the equation (ii)
18.49 kJ = c × (27.93 - 26.74)
c = 18.49 kJ/1.19 °C
c = 15.54 kJ/°C

Q14. A 0.500 g sample of naphthalene ($C_{10}H_8$) is burned in a bomb calorimeter containing 650 grams of water at an initial temperature of 20.00ºC. After the reaction, the final temperature of the water is 26.4ºC. The heat capacity of the calorimeter is 420 J/ºC. Using these data, calculate the heat of combustion of naphthalene in kJ/mol.

Answer. Specific heat capacity of water = 4.18 J/g°C
Calculation of the heat absorbed by water-
q_{water} =mcΔt
m = 650g
C = 4.184 J/g°C
$\Delta t = t_2 - t_1$ (26.4 - 20) = 6.4 °C
q_{water} = 650 g × 4.184 J/g°C × 6.4 °C
q_{water} = 17405.44 J

Calculation of the heat absorbed by calorimeter-
$q_{calorimeter}$ = Heat capacity of calorimeter × rise in temperature
$q_{calorimeter}$ = C × Δt
$q_{calorimeter}$ = 420 J/ºC × 6.4°C = 2688 J

Total heat released during combustion = 17405.44 J + 2688 J = 20.093 kJ
0.5 g of $C_{10}H_8$ releases 20.093 kJ.

Therefore, for 1 mole (130.11g/mol) the amount of heat energy released is- (20.093 kJ × 130.11 g/mol)/0.5 g = 5224.18 kJ/mol
Hence, the heat of combustion of $C_{10}H_8$ = 5224.15 kJ/mol

Q15. The combustion of liquid hexane has a change in internal energy for the reaction ΔE_{rxn} of -3.80 × 10^3 kJ/mol C_6H_{14}. When .50 g of C_6H_{14} reacts in a bomb calorimeter, the temperature rises from 21.9 °C to 43.9 °C. Calculate the heat capacity of the bomb calorimeter in kJ/°C.

Answer. $q_{cal} = C_{cal}\ \Delta T$, $q_{cal} = -q_{rxn}$, $q_{rxn} = \Delta E_{rxn}$
$C_{cal} = -\Delta E_{rxn} / \Delta T$
$\Delta E_{rxn} = 2.50\ g\ C_6H_{14} \times (1\ mol\ C_6H_{14} / 86.172\ g\ C_6H_{14}) \times (-3.80 \times 10^3\ kJ / 1 mol\ C_6H_{14})$
$\Delta E_{rxn} = -110 kJ$
$C_{cal} = -(-110 kJ) / (43.9 - 21.9)°C = 5.01\ kJ/°C$

Practise Questions on Bomb Calorimeter

Q1. Which property of the system under investigation is most likely to remain constant when a bomb calorimeter is used to determine the heat of reaction?

a.) The number of molecules
b.) Pressure
c.) Temperature
d.) Volume

Correct Answer- (d.) Volume

Q2. The heat liberated when 1.89 g of benzoic acid is burnt in a bomb calorimeter at 25 ℃ increases the temperature of 18.4 kg of water by 0.632 ℃. If the specific heat of water at 25 ℃ is 0.998 cal/g-deg, the value of the heat combustion of benzoic acid is-

a.) 771.1 kcal
b.) 871.2 kcal
c.) 881.1 kcal
d.) 981.1 kcal

Correct Answer- (a.) 771.1 kcal
Explanation– Heat gained by water or heat liberated by benzoic acid (Q) = $ms\Delta t = 18940 \times 0.998 \times 0.632 = 11946.14$ cal.
Since 1.89 g of acid liberates 11946.14 cal of heat.
Therefore, the heat liberated by 122 g of acid = (11946.14 × 122) / 1.89 = 771126.5 cal = 771.1 kcal.

Q3. A bomb calorimeter with a calorimeter constant of 1.23 kJ/℃ contains 0.600 kg of water. How much heat is released when 6.00 grams of sucrose is burned? The temperature of the calorimeter and its contents increase from 23℃ to 50℃.

Answer. C_{cal} = 1.23 kJ/℃, m (H_2O) = 0.600 kg, m (sucrose) = 6 g, ΔT = 27℃, c = 4.184 J/g ℃
$q_{combustion} + q_{cal} + q_{H2O} = 0$
$q_{combustion} + C_{cal}\Delta T + mc\Delta T = 0$
$q_{combustion}$ + (1.23 kJ/℃) (27℃) + (600g) (4.184 J/g ℃)((27℃) = 0
$q_{combustion}$ + 33.21 kJ + 67.78 kJ = 0
$q_{combustion}$ = –100.99 kJ

100.99 kJ heat is released when 6.00 grams of sucrose is burned.

Q4. X g of ethanal was subjected to combustion in a bomb calorimeter and the heat produced is Y J. Then, find the value of $\Delta U_{combustion}$.

Answer.
At constant volume,
x g → Y J
1 g → Y J/x
Therefore, for 1 mole of ethanal (CH_3CHO) that is 44 g of ethanal will give = (44 Y J)/x
$\Delta H_{combustion}$ = – (44 Y)/x J/mol
$\Delta U = \Delta H - P\Delta V$ ($P\Delta V = 0$)
$\Delta U = \Delta H$
$\Delta U_{combustion} = \Delta H_{combustion}$
$\Delta U_{combustion}$ = – (44Y)/x J/mol

Q5. For gas, A in a calorimeter, heat evolved is 250 kJ.mol^{-1}. For 0.2 mol of A, the temperature rise from 298K to 300K. Find out the capacity of the calorimeter.

Answer. $Q = n \times C \times \Delta T$
For 0.2 mole Q = 250 × 0.2 = 50 kJ
ΔT = (300 – 298)K = 2K
Therefore,
50kJ = 1 × C × 2K
C = 25 kJ/ K
Hence, heat capacity of the calorimeter is 25 kJ/K.