Multiple Choice

1) In an insulated coffee-cup calorimeter 100.0 g sample of water was placed at 100.0°C, and a 35.0 g piece of certain metal at 25.0°C was immediately immersed in the water. The temperature of the water-metal system came to 95.5°C. Knowing that the specific heat of water is 4.184 J/g °C, calculate (in J/g °C) the specific heat of that metal.

A) 0.946 B) 0.825 C) 0.763 D) 0.687

2) Naphthalene combustion can be used to calibrate the heat capacity of a bomb calorimeter. The heat of combustion of naphthalene is –40.0 kJ/g. When 0.750 g sample of naphthalene was completely burned inside a constant-volume bomb calorimeter that contains an adequate amount of water, a temperature rise of 6.0°C was observed. Calculate the total heat capacity (in kJ/°C) of this calorimeter.

A) 6.00 B) 5.50 C) 5.00 D) 4.50

3) The combustion of glucose "$C_6H_{12}O_6$" produces heat energy according to:

$C_6H_{12}O_6(s) + 6O_2(g) \longrightarrow 6CO_2(g) + 6H_2O(\ell)$ $\Delta H^o_{rxn} = -2802.8$ kJ

Given: $\Delta H^o_f[CO_2(g)] = -393.5$ kJ/mol, $\Delta H^o_f[H_2O(\ell)] = -285.8$ kJ/mol

Calculate (in kJ/mol) the heat of formation of glucose "ΔH^o_f" (glucose).

A) –2448 B) –2226 C) –1885 D) –1273

4) The combustion of octane "C_8H_{18}" releases heat energy according to:

$2C_8H_{18}(\ell) + 25O_2(g) \longrightarrow 16CO_2(g) + 18H_2O(\ell)$ $\Delta H^o_{rxn} = -11020.8$ kJ

How many grams of octane must be burned to supply 2413 kJ of heat energy.

A) 30 B) 50 C) 60 D) 80

5) A gas is compressed in a cylinder by a constant pressure of 10.0 atm from a volume of 40.0 L and at the same time this gas absorbs 200.0 J of heat energy. Knowing that the change in the internal energy ΔE is 8306.0 J, what is the final volume (in L) of the gas?

A) 28 B) 30 C) 32 D) 34

6) At 25.0°C, wet oxygen gas collected over water at a total pressure of 1.0 atm is soluble to the extent of 0.04 g/L. what would its solubility (in g/L) be if its partial pressure over water was 920.0 torr (knowing that the vapor pressure of water at 25.0°C is 24.0 torr).

A) 0.05 B) 0.06 C) 0.07 D) 0.08

7) The vapor pressure of pure water at 32°C is 35.7 torr. What is the vapor pressure (in torr) over a solution prepared from 200.0 g of urea "$CO(NH_2)_2$" and 350.0 g of water at 32.0°C.

A) 27.3 B) 29.4 C) 28.6 D) 30.5

8) Calculate the van't Hoff factor of Na_3PO_4 in a 0.4 molal aqueous solution whose boiling point is 100.78°C (given K_b water = 0.52°C/*m*).

A) 3.86 B) 3.75 C) 3.65 D) 3.44

9) An aqueous solution of a certain protein contains 0.4 g per liter has an osmotic pressure of 3.73 torr at 26°C. What is the approximate molar mass (in g/mol) of this protein?

A) 2000 B) 2500 C) 3000 D) 3500

10) For the reaction:

$$4NH_3(g) + 3O_2(g) \longrightarrow 2N_2(g) + 6H_2O(g)$$

It was found that at a particular instant, N_2 was being formed at a rate of 1.2 $mol.L^{-1}.s^{-1}$. At what rate (in $mol.L^{-1}.s^{-1}$) was NH_3 being consumed in the same time interval?

A) –2.4 B) –1.8 C) –0.8 D) –0.6

11) The decomposition of C_2H_5Cl has the following rate law: Rate = $k[C_2H_5Cl]$ and at 550.0°C its half-life is 22.0 seconds. If the concentration of C_2H_5Cl is 0.01 mol/L after 1.0 minute, what was the initial concentration (in mol/L) of C_2H_5Cl?

A) 0.066 B) 0.152 C) 0.196 D) 0.219

12) The reaction $CH_3CO \longrightarrow CH_3 + CO$ follows a first order kinetics and has an activation energy of 70.0 kJ/mol. By what factor will the rate constant of this reaction increase when the temperature is raised from 10.0°C to 29.0°C?

A) 3.8 B) 4.9 C) 5.2 D) 6.5

The answer:

1) **For the rate law**:

Rate = k $[NO]^x [Br_2]^y$

$[Br_2]$ was held constant at 0.50 mol/L in experiments (1) and (2) while [NO] changed from 0.35 mol/L to 0.10 mol/L.

$$\frac{\text{the initial rate of experiment (1)}}{\text{the initial rate of experiment (2)}} = \frac{735\ \text{mol/L.s.}}{60\ \text{mol/L.s.}} = 12.25 = \frac{k\,[NO]^x\,[Br_2]^y}{k\,[NO]^x\,[Br_2]^y}$$

$$= \frac{\cancel{k}\,[0.35\ \text{mol/L}]^x\,[\cancel{0.50\ \text{mol/L}}]^y}{\cancel{k}\,[0.10\ \text{mol/L}]^x\,[\cancel{0.50\ \text{mol/L}}]^y} = (3.5)^x$$

$12.25 = (3.5)^x = (3.5)^2$

The reaction is of second order in [NO].

In experiments (2) and (3), the [NO] was held constant at 0.10 mol/L while $[Br_2]$ changed from 0.50 mol/L to 0.20 mol/L.

$$\frac{\text{the initial rate of experiment (2)}}{\text{the initial rate of experiment (3)}} = \frac{60\ \text{mol/L.s.}}{24\ \text{mol/L.s.}} = 2.5 = \frac{k\,[NO]^x\,[Br_2]^y}{k\,[NO]^x\,[Br_2]^y}$$

$$= \frac{\cancel{k}\,[\cancel{0.10\ \text{mol/L}}]^x[0.50\ \text{mol/L}]^y}{\cancel{k}\,[\cancel{0.10\ \text{mol/L}}]^x[0.20\ \text{mol/L}]^y} = (2.5)^x$$

Where "y" is 1.0. Therefore, the reaction is of first order in $[Br_2]$, and the rate law is:

Rate = k $[NO]^2 [Br_2]$

This reaction follows third order kinetics. **(1.0 mark)**

2) **The value of "k":** From any of the three given experiments, say experiment number (1).

735 mol/L.s = k $(0.35\ \text{mol/L})^2$ (0.5 mol/L)

= k $(0.1225\ \text{mol}^2.\text{L}^{-2})(0.5\ \text{mol.L}^{-1})$

= k $(0.06125\ \text{mol}^3.\text{L}^{-3})$

$$k = \frac{735\ \text{mol.L}^{-1}.\text{s}^{-1}}{0.06125\ \text{mol}^3\text{L}^{-3}} = 12000\ \text{mol}^{-2}.\text{L}^2.\text{s}^{-1}$$ **(1.0 mark)**

3) **The initial rate** = 12000 $\text{mol}^{-2}\ \text{L}^2\ \text{s}^{-1}\ (0.30)^2\ \text{mol}^2\ \text{L}^{-2}$ (0.20 mol/L)

= $12000 \times (0.3)^2\ (0.2)\ \text{mol L}^{-1}\ \text{s}^{-1}$

= $216\ \text{mol.L}^{-1}.\text{s}^{-1}$ **(1.0 mark)**