# Sample Chemistry Question (Ch. 3 - 5) - CH 221

**Questions for Chapters Three, Four and Five:**

1. A compound contains by weight 41.4% carbon, 3.47% hydrogen, and 55.1% oxygen. A 0.0500 mole sample of this compound weighs 8.71 g. The molecular formula of the compound is:

a. CHO
b. $C_3H_3O$
c. $C_3H_3O_3$
d. $C_4H_4O_4$
e. $C_6H_6O_6$

2. Many metals react with halogens to give metal halides. For example: Fe(s) + Cl2(g) -> FeCl2(s) If you begin with 10.0 g of iron,

a. You will need 10.0 g of Cl2 for complete reaction and will produce 22.7 g of FeCl2.
b. You will need 12.7 g of Cl2 for complete reaction and will produce 10.0 g of FeCl2.
c. You will need 12.7 g of Cl2 for complete reaction and will produce 22.7 g of FeCl2.
d. You will need 10.0 g of Cl2 for complete reaction and will produce 10.0 g of FeCl2.
e. You will need 10.0 g of Cl2 for complete reaction and will produce 20.0 g of FeCl2.

3. Caffeine has the formula $C_8H_{10}N_4O_2$. If 5.00 mg of caffeine is burned, how many milligrams of $CO_2$ are produced?

a. 1.13 mg
b. 1.76 mg
c. 2.06 mg
d. 9.06 mg
e. 5.67 mg

4. Calculate the enthalpy of reaction for the combustion of 9.25 g of butane, $C_4H_{10}$, using the following standard enthalpies of formation: $CO_2(g)$ = -394 kJ/mol; $H_2O(g)$ = - 286 kJ/mol; $C_4H_{10}(g)$ = -484 kJ/mol

a. -401 kJ
b. -802 kJ
c. +401 kJ

d. +25.6 kJ
e. +201 kJ

5. Find the enthalpy of formation for $PCl_3$ using the following reactions:

$P_4 + 10\ Cl_2 \rightarrow 4\ PCl_5 \quad \Delta H_{rxn} = -1774.0$ kJ
$PCl_3 + Cl_2 \rightarrow PCl_5 \quad \Delta H_{rxn} = -128.8$ kJ

a. -447.3 kJ
b. -314.7 kJ
c. +238.0 kJ
d. +998.4 kJ
e. +87.6 kJ

6. Calculate the quantity of heat required to convert 60.1 g of ice at 0 °C to steam at 100.0 °C using the heat of fusion (333 J/g) and heat of vaporization (2260 J/g) for water.

a. 144 kJ
b. 52.3 kJ
c. 312 kJ
d. 180. kJ
e. 460. kJ

**Here are the answers to the previous questions:**

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1. A compound contains by weight 41.4% carbon, 3.47% hydrogen, and 55.1% oxygen. A 0.0500 mole sample of this compound weighs 8.71 g. The molecular formula of the compound is:

a. CHO
b. $C_3H_3O$
c. $C_3H_3O_3$
d. $C_4H_4O_4$
e. $C_6H_6O_6$

Answer: Assume you have 100 g of the compound. This means you will have 41.4 g C, 3.47 g H and 55.1 g O.

Convert these to moles: (41.4 g C / 12.01) = 3.45 mol C; (3.47 g H / 1.008) = 3.45 mol H; (55.1 g O / 16.00) = 3.44 mol O

Now find empirical formula by dividing moles by smallest quantity; note that in this problem, the mol of C, H and O are similar (i.e. all are about 3.45 mol). We can write this as **CHO = Empirical Formula**

To find the molecular formula, we need a molar mass; this can be accomplished by dividing the 8.71 g by 0.0500 mol = 174 g/mol in molecular formula

The empirical formula, CHO, is (12.01 + 1.008 + 16.00) = 29.02 g/mol, and this is roughly 1/6th of 174 g/mol

So final formula is **(e), C6H6O6**

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2. Many metals react with halogens to give metal halides. For example: Fe(s) + Cl2(g) –> FeCl2(s) If you begin with 10.0 g of iron,

a) You will need 10.0 g of Cl2 for complete reaction and will produce 22.7 g of FeCl2.
b) You will need 12.7 g of Cl2 for complete reaction and will produce 10.0 g of FeCl2.
c) You will need 12.7 g of Cl2 for complete reaction and will produce 22.7 g of FeCl2.
d) You will need 10.0 g of Cl2 for complete reaction and will produce 10.0 g of FeCl2.
e) You will need 10.0 g of Cl2 for complete reaction and will produce 20.0 g of FeCl2.

Answer: First find g of Cl2 required to react with 10.0 g Fe by converting the g of Fe to moles, then to moles of Cl2 and then to g of Cl2:

10.0 g Fe * (mol Fe / 55.85 g Fe) * (1 mol Cl2 / 1 mol Fe) * (70.9 g Cl2 / mol Cl2) = **12.7 g Cl2**

Next, find how much FeCl2 will be made using the 10.0 g of Fe by converting to moles Fe, then to moles of FeCl2 and finally to g of FeCl2:

10.0 g Fe * (mol Fe / 55.85 g Fe) * (1 mol FeCl2 / 1 mol Fe) * (126.8 g FeCl2 / mol FeCl2) = **22.7 g FeCl2**

Alternatively, you could use law of mass action to find g of product by taking 10.0 g of Fe and adding to the 12.7 g of Cl2 needed (as calculated above) to find the 22.7 g of FeCl2.

The answer to this problem is **(c), 12.7 g of Cl2 for complete reaction and will produce 22.7 g of FeCl2.**

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3. Caffeine has the formula $C_8H_{10}N_4O_2$. If 5.00 mg of caffeine is burned, how many milligrams of $CO_2$ are produced?

a. 1.13 mg
b. 1.76 mg
c. 2.06 mg
d. 9.06 mg
e. 5.67 mg

Answer: This is a combustion reaction, so write out the equation:

$C_8H_{10}N_4O_2 + x\ O_2 \rightarrow y\ CO_2 + z\ H_2O + a\ NO_2$

We only need the relationship between caffeine and $CO_2$, and since all the carbon in $CO_2$ comes from caffeine, there will be 8 mol of $CO_2$ per mol of caffeine. Therefore:

5.00 mg * (1 g/1000 mg) * (1 mol caffeine / 194.19 g) * (8 mol $CO_2$ / 1 mol caffeine) * (44.01 g $CO_2$ / mol $CO_2$) * (1000 mg / g) = **9.06 mg, answer d**.

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4. Calculate the enthalpy of reaction for the combustion of 9.25 g of butane, $C_4H_{10}$, using the following standard enthalpies of formation: $CO_2(g) = -394$ kJ/mol; $H_2O(g) = -286$ kJ/mol; $C_4H_{10}(g) = -484$ kJ/mol

a. -401 kJ
b. -802 kJ
c. +401 kJ
d. +25.6 kJ
e. +201 kJ

Answer: This is also a combustion reaction, and the equation will be:

$C_4H_{10} + {}^{13}/_2\ O_2 \rightarrow 4\ CO_2 + 5\ H_2O$

The enthalpy of reaction, $\Delta H_{rxn}$, will equal the enthalpies of the products minus the enthalpies of reactants. In this case,

$\Delta H_{rxn} = (4*\Delta H_f(CO_2) + 5*\Delta H_f(H_2O)) - (\Delta H_f(C_4H_{10}) + {}^{13}/_2*\Delta H_f(O_2))$

Notice the stoichiometric coefficients; heat of formation values ($\Delta H_f$) are calculated per mole, so if more than one mole is present, a coefficient must be added on to account for the energy.

Remember that elements in their standard states have enthalpies equal to zero; hence, $\Delta H(O_2) = 0$. Therefore,

$\Delta H_{rxn} = (4*(-394) + 5*(-286)) - ((-484) + {}^{13}/_2*0) = -3006 + 484 = -2522$ kJ/mol butane

To find the enthalpy of reaction for 9.25 g, convert the mass to moles and multiply:

9.25 g butane * (mol butane / 58.123 g) * (-2522 kJ / mol butane) = **-401 kJ, answer a.**

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5. Find the enthalpy of formation for $PCl_3$ using the following reactions:

$P_4 + 10\ Cl_2 \rightarrow 4\ PCl_5 \quad \Delta H_{rxn} = -1774.0$ kJ
$PCl_3 + Cl_2 \rightarrow PCl_5 \quad \Delta H_{rxn} = -128.8$ kJ

a. -447.3 kJ
b. -314.7 kJ
c. +238.0 kJ
d. +998.4 kJ
e. 87.6 kJ

Answer: The heat of formation reaction for $PCl_3$ would be written as:

$1/4\ P_4 + 3/2\ Cl_2 \rightarrow PCl_3$

Heat of formation equations always have one mole of product and reactants which are elements in their standard states. Combining the first given equation with the four times the reverse of the second given equation leads to:

$P_4 + 10\ Cl_2 \rightarrow 4\ PCl_5 \quad \Delta H_{rxn} = -1774.0$ kJ
$4\ PCl_5 \rightarrow 4\ PCl_3 + 4\ Cl_2 \quad \Delta H_{rxn} = -4*(-128.8\ kJ) = 515.2$ kJ
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$P_4 + 6\ Cl_2 \rightarrow 4\ PCl_3 \quad \Delta H_{rxn} = -1774.0 + 515.2 = -1258.8$ kJ

To get the resulting equation in a form comparable to the heat of formation equation for $PCl_3$, divide by 4 to get:

$1/4\ P_4 + 3/2\ Cl_2 \rightarrow PCl_3 \quad \Delta H_{rxn} = 0.25*(-1258.8\ kJ) =$ **-314.7 kJ, answer (b)**

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6. Calculate the quantity of heat required to convert 60.1 g of ice at 0 °C to steam at 100.0 °C using the heat of fusion (333 J/g) and heat of vaporization (2260 J/g) for water.

a. 144 kJ
b. 52.3 kJ
c. 312 kJ
d. 180. kJ
e. 460. kJ

Answer: There are 3 calculations in this problem, all of which will be combined to find the total heat required to turn the ice into steam. The first calculation will convert the

solid ice to liquid water using the heat of fusion. The second calculation will heat the liquid water from 0 to 100 degrees. The third calculation will transform the liquid water into steam (gas) using the heat of vaporization.

To turn the ice to water:

$q = 333\ J/g * 60.1\ g = 2.00*10^4\ J$

To heat the water from 0 to 100 °C:

$q = mC\Delta T = 60.1\ g * 4.184\ J/gC * (100 - 0) = 2.51*10^4\ J$

To turn the liquid water into steam:

$q = 2260\ J/g*60.1\ g = 1.36*10^5\ J$

Therefore, to convert the ice to steam takes $1.36*10^5\ J + 2.51*10^4\ J + 2.00*10^4\ J =$ **$1.80*10^5$ J, or 180. kJ, answer (d)**.