Relay Round

Group (a) will be able to solve their problem in its entirety. Group (b) will be passed a unit-less numerical answer from group (a), which is to be entered in the blank indicated by _____. This answer provided by group (a) will allow group (b) to complete solving their problem. This answer will be passed to group (c), which will enter the answer received from group (b) in the blank indicated by _____. This will allow group (c) to answer their problem. Group (c)'s answer will then be graded.

1) The answer you will receive from the previous group is indicated by _____.

a) Given that the equilibrium constant of the formation of PCl_5 in the following reaction is 0.34:

$$PCl_3 + Cl_2 \rightleftarrows PCl_5 \qquad K_{eq} = 0.34$$

What is the equilibrium constant for the following reaction?

$$\tfrac{1}{3}PCl_5 \rightleftarrows \tfrac{1}{3}PCl_3 + \tfrac{1}{3}Cl_2$$

$$K_{eq} = \left(\frac{1}{0.34}\right)^{\frac{1}{3}} = 1.433$$

Report this answer to **three** decimal places, without any units, to the next group.

b) Given the following equations and their associated enthalpies:

$C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(g)}$ $\quad \Delta H_a = 4.99$ kJ/mol

$C_{(graphite)} + O_{2(g)} \rightarrow CO_{2(g)}$ $\quad \Delta H_b = 2.04$ kJ/mol

$H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)}$ $\quad \Delta H_c =$ (_____) kJ/mol

Calculate ΔH (in kJ/mol) for the following reaction:

$$3C_{(graphite)} + 4H_{2(g)} \rightarrow C_3H_{8(g)}$$

$$\Delta H_{rxn} = 3\Delta H_b - \Delta H_a + 4\Delta H_c = 3\left(2.04\frac{kJ}{mol}\right) - 4.99\frac{kJ}{mol} + 4\left(1.433\frac{kJ}{mol}\right)$$
$$= 6.86\frac{kJ}{mol}$$

Report this answer, without units, to the next group.

c) Given the following information:

$Ce^{3+}_{(aq)} + 3e^- \rightarrow Ce_{(s)}$ ε° = -2.48 V

$Ce^{4+}_{(aq)} + e^- \rightarrow Ce^{3+}_{(aq)}$ ε° = [(1/10)∗(_____)] V

What is E^o (in volts) for the following reaction:

$Ce^{4+}_{(aq)} + 4e^- \rightarrow Ce_{(s)}$

$$\Delta G = -nF\varepsilon^\circ$$

$$\Delta G_{rxn\,1} = -3\left(96500\frac{C}{mol\ e^-}\right)(-2.48V) = 717.96\frac{kJ}{mol}$$

$$\Delta G_{rxn\,2} = -1\left(96500\frac{C}{mol\ e^-}\right)(0.6862V) = -66.22\frac{kJ}{mol}$$

$$\Delta G_{rxn} = 717.96\frac{kJ}{mol} - 66.22\frac{kJ}{mol} = 651.74\frac{kJ}{mol}$$

$$E_{rxn}{}^\circ = \frac{-\Delta G_{rxn}}{nF} = \frac{-651740\frac{J}{mol}}{4 * 96500\frac{C}{mol\ e^-}} = -1.69V$$

2) The answer you will receive from the previous group is indicated by _____

a) A gaseous hydrocarbon (a compound that consists solely of carbon and hydrogen atoms) is found to be 88.8% C and 11.2 % H by mass. Find the empirical formula of the compound and pass it on to the next group.

Assume 100 g of hydrocarbon. This would result in a molecular formula of $C_{7.393}H_{11.11}$. This simplifies to an empirical formula of C_2H_3.

b) A compound has a density of 2.12 g/L at 31 °C and 742 torr. Given that the empirical formula is (_____), determine the molecular formula of this compound, and pass this molecular formula to the next group.

$$Molar\ Mass = \frac{density * R * T}{P} = \frac{2.12\frac{g}{L} * 0.0821\ \frac{L * atm}{K * mol} * 304K}{0.9763158\ atm} = 54.2\frac{g}{mol}$$

$$Molecular\ Formula\ is\ C_4H_6$$

c) Draw all possible non-cyclical structures for the compound (_____) (there are 4), and one of the two possible cyclical structures. Circle the structures that have one or more triple bonds.

5 correct structures should be given. 2 straight-chain alkynes should be circled; one has the triple bond between the first and second carbons, other has the triple bond between the central carbons.