Hess's Law
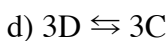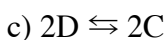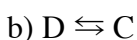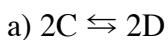
Solve the following problems on a separate sheet of paper.

1) Consider the following reaction:
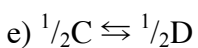
$$C \leftrightharpoons D \qquad\qquad\qquad \Delta H° = 20 \text{ kJ}$$
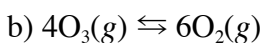
Find the enthalpy change for the following reactions:

a) $2C \leftrightharpoons 2D$

b) $D \leftrightharpoons C$

c) $2D \leftrightharpoons 2C$

d) $3D \leftrightharpoons 3C$

e) $\frac{1}{2}C \leftrightharpoons \frac{1}{2}D$

2) Consider the following thermochemical equation:

$$2O_3(g) \leftrightharpoons 3O_2(g) \qquad\qquad\qquad \Delta H° = -1300 \text{ kJ}$$

Find the enthalpy change for the following reactions:

a) $3O_2(g) \leftrightharpoons 2O_3(g)$

b) $4O_3(g) \leftrightharpoons 6O_2(g)$

c) $O_3(g) \leftrightharpoons \frac{3}{2}O_2(g)$

d) $\frac{3}{2}O_2(g) \leftrightharpoons O_3(g)$

e) $6O_3(g) \leftrightharpoons 9O_2(g)$

3)   Given the following data:

$$N_2(g) + 2O_2(g) \leftrightharpoons 2NO_2(g) \qquad\qquad \Delta H° = 67.7 \text{ kJ}$$
$$N_2(g) + 2O_2(g) \leftrightharpoons N_2O_4(g) \qquad\qquad \Delta H° = 9.8 \text{ kJ}$$
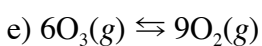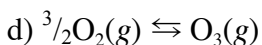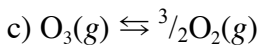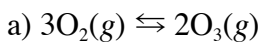
Calculate $\Delta H°$ for the dimerization of NO_2:
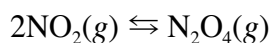
$$2NO_2(g) \leftrightharpoons N_2O_4(g)$$

4)   Given the following data:
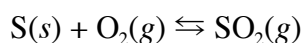
$$S(s) + \frac{3}{2}O_2(g) \leftrightharpoons SO_3(g) \qquad\qquad \Delta H° = -395.2 \text{ kJ}$$
$$SO_2(g) + \frac{1}{2}O_2(g) \leftrightharpoons SO_3(g) \qquad\qquad \Delta H° = -99.1 \text{ kJ}$$

Calculate $\Delta H°$ for the reaction

$$S(s) + O_2(g) \leftrightharpoons SO_2(g)$$

5) Use the following thermochemical equations:

$N_2(g) + 2O_2(g) \leftrightharpoons 2NO_2(g)$ $\Delta H° = 66.4$ kJ

$2NO(g) + O_2(g) \leftrightharpoons 2NO_2(g)$ $\Delta H° = -114.1$ kJ

To find the enthalpy change for:

$\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \leftrightharpoons NO(g)$

6) Use the following thermochemical equations:

$Zn(s) + S(s) \leftrightharpoons ZnS(s)$ $\Delta H° = -206.1$ kJ

$ZnS(s) + 2O_2(g) \leftrightharpoons ZnSO_4(s)$ $\Delta H° = -776.8$ kJ

To find the enthalpy change for:

$Zn(s) + S(s) + 2O_2(g) \leftrightharpoons ZnSO_4(s)$
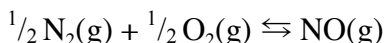
7) Use the following equations to calculate the enthalpy change for the following:

$H_2(g) + Cl_2(g) \leftrightharpoons 2HCl(g)$ $\Delta H° = ?$

$NH_3(g) + HCl(g) \leftrightharpoons NH_4Cl(s)$ $\Delta H° = -176.0$ kJ

$N_2(g) + 3H_2(g) \leftrightharpoons 2NH_3(g)$ $\Delta H° = -92.22$ kJ

$N_2(g) + 4H_2(g) + Cl_2(g) \leftrightharpoons 2NH_4Cl(s)$ $\Delta H° = -628.86$ kJ

8)   Given the following data:

$H_2(g) + \frac{1}{2}O_2(g) \leftrightharpoons H_2O(l)$ $\Delta H° = -285.8$ kJ

$N_2O_5(g) + H_2O(l) \leftrightharpoons 2HNO_3(l)$ $\Delta H° = -76.6$ kJ

$\frac{1}{2}N_2(g) + \frac{3}{2}O_2(g) + \frac{1}{2}H_2(g) \leftrightharpoons HNO_3(l)$ $\Delta H° = -174.1$ kJ
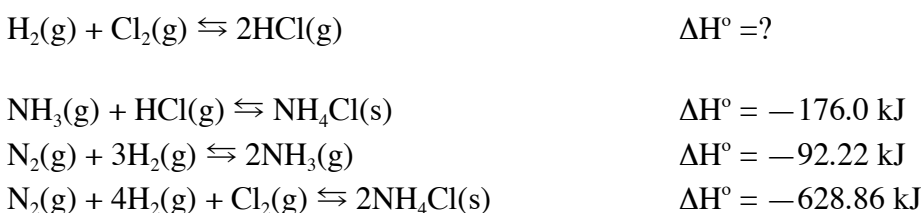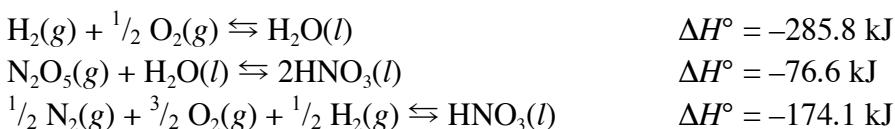
Calculate the $\Delta H°$ for the reaction

$$2N_2(g) + 5O_2(g) \leftrightharpoons 2N_2O_5(g)$$

9)   Given the following data

$2O_3(g) \leftrightharpoons 3O_2(g)$ $\Delta H° = -1300$ kJ

$O_2(g) \leftrightharpoons 2O(g)$ $\Delta H° = +495$ kJ

$NO(g) + O_3(g) \leftrightharpoons NO_2(g) + O_2(g)$ $\Delta H° = -199$ kJ

Calculate $\Delta H°$ for the reaction

$$NO(g) + O(g) \leftrightharpoons NO_2(g)$$

10)   Given the following data

$O_2(g) + H_2(g) \leftrightharpoons 2OH(g)$ $\Delta H° = +77.9$ kJ

$O_2(g) \leftrightharpoons 2O(g)$ $\Delta H° = +495$ kJ

$H_2(g) \leftrightharpoons 2H(g)$ $\Delta H° = +435.9$ kJ

Calculate $\Delta H°$ for the reaction

$$O(g) + H(g) \leftrightharpoons OH(g)$$