Assessor's use only

QUESTION THREE : ENTHALPY CHANGES

(a) Urea, $(NH_2)_2CO$, which is a white crystalline solid, is widely used as a fertiliser.
Write the equation for which the enthalpy change is:

(i) the enthalpy of formation, $\Delta_f H°$, for urea

(ii) the enthalpy of fusion, $\Delta_{fus} H°$, for urea

(b) Urea breaks down in moist soil into carbon dioxide and ammonia.

$$(NH_2)_2CO(s) + H_2O(\ell) \rightarrow CO_2(g) + 2NH_3(g)$$

Calculate the enthalpy change for this reaction, $\Delta_r H$, using the information below.

$$(NH_2)_2CO(s) + 3\tfrac{1}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(\ell) + 2NO_2(g) \quad \Delta_r H = -632 \text{ kJ mol}^{-1}$$
$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g) \quad \Delta_r H = -906 \text{ kJ mol}^{-1}$$
$$NO(g) + \tfrac{1}{2}O_2(g) \rightarrow NO_2(g) \quad \Delta_r H = -57 \text{ kJ mol}^{-1}$$
$$H_2O(\ell) \rightarrow H_2O(g) \quad \Delta_{vap} H = +41 \text{ kJ mol}^{-1}$$