2024 Higher Chemistry Paper 1 – Q21

Section: Chemistry in Society
Topic: Chemical Energy (Hess's Law)

Question summary (Q21):
Four reactions with enthalpy changes a, b, c, d are given. The task is to find the correct relationship between them using Hess's law.

Worked Solution:
• Reactions:
1. $C(s) + H_2(g) + O_2(g) \rightarrow HCOOH(\ell)$ $\Delta H = a$
2. $HCOOH(\ell) + \frac{1}{2}O_2(g) \rightarrow CO_2(g) + H_2O(\ell)$ $\Delta H = b$
3. $C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H = c$
4. $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(\ell)$ $\Delta H = d$

• Adding (1) and (2):
$C + H_2 + O_2 \rightarrow HCOOH$
$HCOOH + \frac{1}{2}O_2 \rightarrow CO_2 + H_2O$
Gives overall: $C + H_2 + 1.5O_2 \rightarrow CO_2 + H_2O$, with $\Delta H = a + b$.

• Compare with (3) + (4):
$C + O_2 \rightarrow CO_2$
$H_2 + \frac{1}{2}O_2 \rightarrow H_2O$
Gives: $C + H_2 + 1.5O_2 \rightarrow CO_2 + H_2O$, with $\Delta H = c + d$.

• Therefore: $a + b = c + d \rightarrow a = c + d - b$.

Final Answer: A — $a = c + d - b$

Revision Tips:
• Hess's Law: overall enthalpy change = sum of enthalpy changes for steps leading to same reaction.
• Write out reactions clearly and cancel intermediates.
• Always check that the overall equations match before comparing ΔH values.