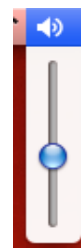


6. Energy Diagrams: Introduction

Diagrams vs. Graphs

Both diagrams and graphs are used in chemistry to help represent physical phenomena. Most graphs show the relationship of two variables, such as distance and time, or frequency and wavelength. Diagrams, however, are a bit trickier. One of the simplest diagrams you will see in chemistry is a one dimensional scale, showing values of only one variable. An example of this type of diagram is one you have seen on your computer – a volume scale. While there are no values shown on this diagram, you know that the higher the knob is, the greater the volume and *visa versa*. In chemistry, we use a similar diagram structure when we talk about energy and different chemical reactions. These are called: *Energy Diagrams*.

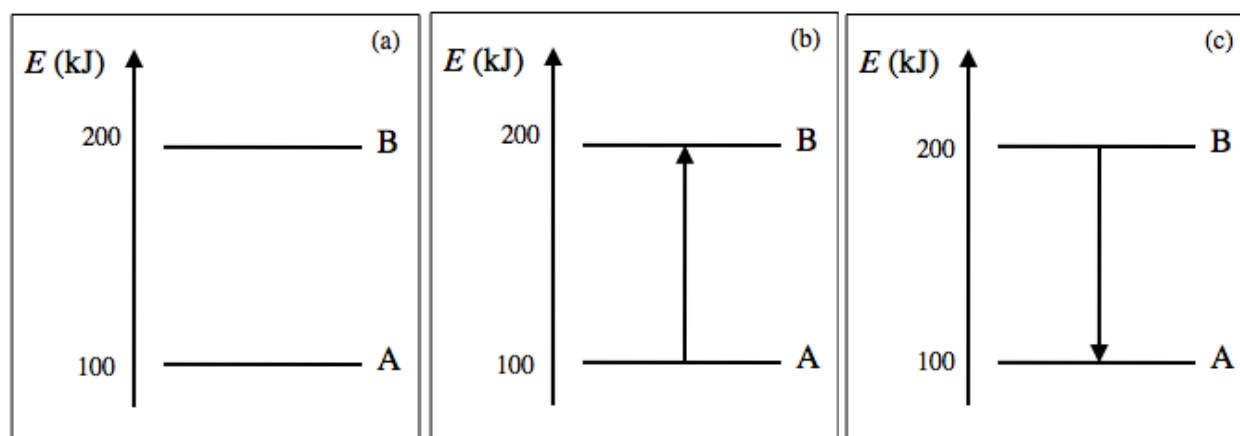


Energy Diagrams

In chemistry, we use a vertical scale to show energy values. In the figures below, you'll notice that the scale is pointing upwards, indicating that the scale can increase infinitely upwards if necessary. Next to that scale, we use horizontal lines to indicate a particular value of energy, and arrows between these values to show change in energy. The size of the horizontal lines do not matter, only their vertical location along the scale.

For example, image (a) below shows two different energy states, A and B, with their associated energies, 100 kJ and 200 kJ, respectively. The states are drawn as horizontal lines, or platforms, so that we can use them to draw different changes in energy. In the middle diagram (b), we have drawn an arrow pointing from the lower energy level, A, to the higher one, B. This means that some physical phenomenon, like a chemical reaction, state "A" is transformed into state "B" (the reaction would be written as $A \rightarrow B$). The change in energy, ΔE , is calculated as the difference between the final energy and initial energy:

$$\Delta E_{A \text{ to } B} = E_{\text{final}} - E_{\text{initial}} = 200 \text{ kJ} - 100 \text{ kJ} = +100 \text{ kJ}.$$

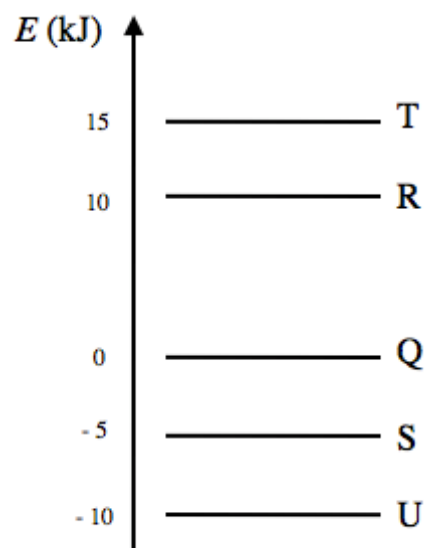


The diagram on the right (c) shows the reverse of this phenomenon (where B is the initial state and A is the final state), where the energy decreases from 200 kJ to 100 kJ ($\Delta E_{B \text{ to } A} = -100 \text{ kJ}$).

Reading Energy Diagrams

From the diagram given on the right, answer the following questions:

1) What is the change in energy from Q to S? ($\Delta E_{Q \text{ to } S}$).



2) What is the change in energy from R to T? ($\Delta E_{R \text{ to } T}$)

3) What transitions result in -20 kJ ? Write the 'reactions' for each.

4) What transitions result in $+15 \text{ kJ}$?

Drawing Energy Diagrams

Draw energy diagrams for each of the following situations

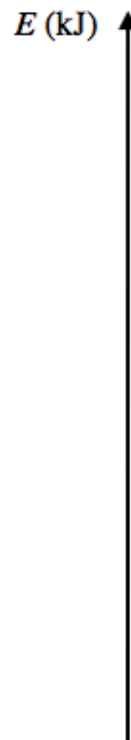
- 1) The energy of "B" is 10 kJ greater than the energy of "A". "A" is 30 kJ ($E_A = 30 \text{ kJ}$).
- Draw in the energy levels of A and B on the diagram.
 - Write the "reaction" for the process of A becoming B. On the diagram, label the states as "initial" and "final."



c) On your diagram, draw the arrow corresponding to $\Delta E_{A \text{ to } B}$.

3) Below are energy transitions between energy levels F, G, H and I. Using these transitions, draw one diagram that shows all four energy levels in the appropriate order and with the appropriate energy values.

- a) $E_F = 10 \text{ kJ}$
- b) $\Delta E_{I \text{ to } F} = +10 \text{ kJ}$
- c) $\Delta E_{I \text{ to } H} = +20 \text{ kJ}$
- d) $\Delta E_{F \text{ to } G} = +5 \text{ kJ}$
- e) $\Delta E_{G \text{ to } I} = -15 \text{ kJ}$



Make your own diagram

Burning one mole of carbon, $C(s)$, in oxygen, $O_2(g)$, to form carbon dioxide, $CO_2(g)$, releases 400 kJ of energy. Draw an energy level diagram to depict this transformation. What is the “initial state”? What is the “final state”?