Solutions

Each answer shows the steps, then the **result**.

2.1

- the electron can only have **certain fixed energies** — never values in between

2.2

- $hf = E_2 - E_1$

2.3

- energy is measured from 0 for a **free** electron, and a bound electron has **less** energy than that — so it is negative

2.4

- a series of **sharp bright lines** on a dark background

3.1 C

- an emission spectrum is **bright lines on a dark background**

3.2

- $\Delta E = E_2 - E_1$

$$\Delta E = -3.4 \text{ eV} - (-13.6 \text{ eV}) = \mathbf{10.2} \text{ eV}$$
$$10.2 \times 1.6 \times 10^{-19} \text{ J eV}^{-1} = \mathbf{1.6 \times 10^{-18}} \text{ J}$$

3.3

- $\lambda = hc/E$

$$\lambda = \frac{(6.63 \times 10^{-34} \text{ J s})(3.0 \times 10^{8} \text{ m s}^{-1})}{1.6 \times 10^{-18} \text{ J}} = \mathbf{1.2 \times 10^{-7}} \text{ m}$$

3.4

- the energy levels are **discrete**
- so the differences $E_2 - E_1$ — and hence the photon energies/wavelengths — can only take **certain values**

3.5

(a) an atom emits a photon when an electron falls from a higher level to a lower one, and the photon energy equals the **difference** between the two levels

- since $E = hf$, one energy difference gives one frequency and so one sharp line
- a continuous range of energies would give a continuous spectrum, so sharp lines show only **certain** energies are allowed, i.e. the levels are discrete

(b) $-13.6 \times 1.60 \times 10^{-19} = \mathbf{-2.18 \times 10^{-18}}$ J

(c) $-3.40 - (-13.6) = \mathbf{10.2}$ eV

(d) differences: 10.2, 12.09 and 12.75 eV

- wavelengths from $\lambda = hc/E$: 122 **nm**, 103 **nm** and 97 **nm**

(e) **no**

- all three lie near 100 nm, in the **ultraviolet**, well below the roughly 400–700 nm visible range

(f) the zero of energy is taken as the electron being **free**, at infinity and at rest

- a bound electron has less energy than that, so energy must be **supplied** to free it and its energy is written as negative