Checkpoints Chapter 17
Energy Levels of Atoms

Question 716

If 1eV = 1.6×10^{-19}J
$\therefore$2.6 keV = $2.6 \times 10^{3} \times 1.6 \times 10^{-19}$
= 4.2×10^{-16}
$\therefore$ **4.2×10^{-16}J (ANS)**

Question 717

If the atoms have an energy level of 2.6 keV, then as it returns to its rest level it will give off photons with the following energies. These photons will be given off as the atom falls from a higher energy level to a lower energy level. So the differences between the energy levels are equal to the energy of the emitted photon

2.6 – 0.4 = 2.2 keV
2.6 – 0.2 = 2.4 keV
2.6 – 0 = 2.6 keV
0.4 – 0.2 = 0.2 keV
0.4 – 0 = 0.4 keV
$\therefore$ **B, C, D (ANS)**

Question 718

To be able to absorb the photon the atom has to be able to accept all the energy of the photon as it moves from one energy level to another. The only energy level above 2.6 keV is 20 keV,

20 – 2.6 = 17.4

So the atom needs to absorb a 17.4 keV photon.
$\therefore$ **A (ANS)**

Question 719

For the atom to return to its ground state, (its preferred option), then it needs to give of photons as it loses energy. We don't know what the values of the energies are, so the photons will have the energy corresponding to the difference between two different energy levels.

Eg. $E_3 - E_2$, $E_3 - E_1$, $E_3 - E_0$,
$E_2 - E_1$, $E_2 - E_0$, $E_1 - E_0$.

We are only interested in the magnitudes of these differences, (so $E_2 - E_1 = E_1 - E_2$)
$\therefore$ **B, C (ANS)**

Question 720

It will be able to absorb photons to take it to another energy level. If you assume that E_3 is higher than the possible photon energies are $E_3 - E_1$, and $E_2 - E_1$.
$\therefore$ **$E_3 - E_1$, and $E_2 - E_1$ (ANS)**

Question 721

The neon atom was at its lowest state, 1.07×10^{-18}
Then to get to either of the other two states its energy needs to increase by

$4.30 \times 10^{-18} - 1.07 \times 10^{-18} = 3.23 \times 10^{-18}$J
$3.97 \times 10^{-18} - 1.07 \times 10^{-18} = 2.90 \times 10^{-18}$J

This will correspond to photon frequencies of
E = hf

$$\therefore f = \frac{E}{h} = \frac{3.23\times10^{-18}}{6.63\times10^{-34}} = 4.87 \times 10^{15} \text{ Hz}$$

and
$$\therefore f = \frac{E}{h} = \frac{2.90\times10^{-18}}{6.63\times10^{-34}} = 4.37 \times 10^{15} \text{ Hz}$$

4.87×10^{15} Hz, 4.37×10^{15} Hz (ANS)

Question 722

An orbit of radius 100 pm will have a circumference of 628 pm, which is twice the wavelength. This will allow for a standing wave pattern.
$\therefore$ **Yes (ANS)**

Question 723

$$\text{Since } E = \frac{hc}{\lambda}$$
$$\therefore \lambda = \frac{hc}{E}$$
$$\therefore \lambda = \frac{4.14\times10^{-15}\times3\times10^{8}}{5.9}$$
$\therefore$ **2.11×10^{-7} m (ANS)**

Question 724

Since the ground state is –13.6 eV, then an atom excited to the –1.50 eV level can return to ground state in a variety of ways.

-1.50 → -13.6

-1.50 → -3.40 → -13.6.

These paths would cause the emission of photons with energies of -1.50 → -13.6 = 12.1 eV

-1.50 → -3.40 = 1.9 eV

-3.40 → -13.6 = 10.2 eV

∴ **B** **(ANS)**

Question 725

A

Is possible if the atom goes from

–0.85 → -3.40 → -13.6

B

Is possible if the atom goes from

–0.85 → -1.50 → -3.40

C

Is possible if the atom goes from

–0.85 → -1.50 → -13.6

∴ D is not possible, because if the atom emitted a 12.75 eV photon it would then be in the ground state. It can't then emit another photon.

∴ **D** **(ANS)**

Question 726

A

Is possible if the atom goes from

–0.85 → -3.40 → -13.6

B

Is possible if the atom goes from

–0.85 → -1.50 → -3.40

C

Is possible if the atom goes from

–0.85 → -1.50 → -13.6

Question 727

The atom needs to absorb all the energy of the photon. So the photon energy needs to be equal to the difference between the ground state and one of the energy levels.

From this chart Hydrogen can absorb photons of energy 12.75 eV, 12.1 eV, 10.2 eV.

∴ A = 10.2 eV.

The photon would excite the atom to the –3.4 eV state.

∴ **A** **(ANS)**

Question 728

The ratio $\frac{h}{p}$ gives the de Bröglie wavelength of the electron.

∴ **D** **(ANS)**

Question 729

For the electron to be in a stable orbit, it needs to be a standing wave, where the circumference of the orbit wavelength is a multiple number of wavelengths.

∴ **A** **(ANS)**

Question 730 **(2010 Q11, 2m, 60%)**

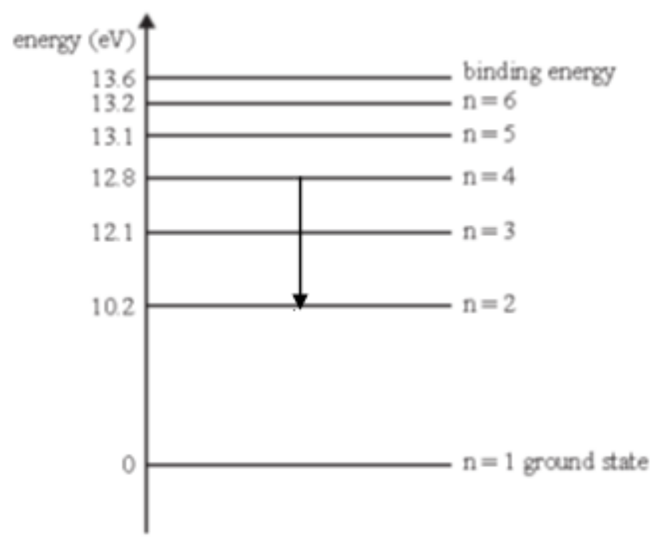
The energy can be found from: $E = \frac{hc}{\lambda}$

$$\therefore\ E = \frac{4.14\times10^{-15}\times3\times10^{8}}{478\times10^{-9}}$$

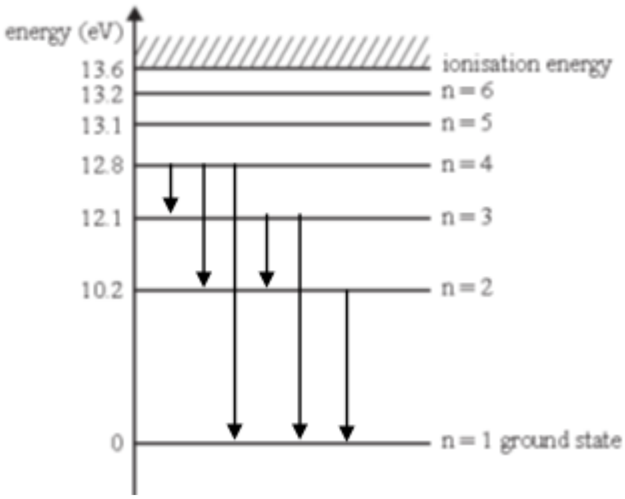
= 2.598

= 2.6 eV.

This is the result of a transition from 12.8 eV to 10.2 eV.



Question 731 (2011 Q13, 3m, 63%)



From left to right
a. 12.8 - 12.1 = **0.7 eV**
b. 12.8 - 10.2 = **2.6 eV**
c. 12.8 - 0 = **12.8 eV**
d. 12.1 - 10.2 = **1.9 eV**
e. 2.1 - 0 = **12.1 eV**
f. 10.2 - 0 = **10.2 eV**

Question 732 (2012 Q4a, 2m, 75%)

The gain in energy is 12.8 – 10.2
= 2.6 eV

Use $\Delta E = \frac{hc}{\lambda}$

$\therefore 2.6 = \frac{4.14 \text{ x}10^{-15} \times 3.0 \times 10^8}{\lambda}$

$\therefore \lambda = \frac{4.14 \text{ x}10^{-15} \times 3.0 \times 10^8}{2.6}$

$\therefore$ **λ = 478 nm (ANS)**

Question 733 (2012 Q4b, 3m, 40%)

Electrons exhibit wavelike properties. As they orbit the nucleus they must form standing waves. This means that only whole numbers of wavelengths can exist. i.e the wavelength is quantised.
The energy of the electron is related to its wavelength, hence energies are quantised.

Question 734 (2013 Q20a, 2m, 40%)

Using $\Delta E = \frac{hc}{\lambda}$, the longest wavelength implies the smallest energy transition. The smallest energy transition is from 3.19 to 2.11 eV. (When the atom is in the 3.19 eV state).
$\therefore$ 3.19 – 2.11 = 1.08 eV

From $\Delta E = \frac{hc}{\lambda}$

$\therefore \lambda = \frac{hc}{E}$

$\therefore \lambda = \frac{4.14 \times 10^{-15} \times 3 \times 10^8}{1.08}$

$\therefore$ **λ = 1.15 × 10^{-6} m (ANS)**

Question 735 (2013 Q20b, 3m, 44%)

Using $\Delta E = \frac{hc}{\lambda}$

$\therefore \Delta E = \frac{4.14 \times 10^{-15} \times 3 \times 10^8}{588.63 \times 10^{-9}}$

$\therefore \Delta E$ = 2.11 eV
This corresponds to the transition from n= 2 (first excited state) to n = 1 (ground state).

Question 736 (2014 Q22a, 2m, 40%)

If the atom is in the first excited state it has an energy value of 4.9 eV. It can absorb a 1.8 eV photon as this will raise it to the 6.7 eV energy level.
If the atom was in its first excited state, at 4.9 eV, the only photon that it can emit will be one of 4.9 eV. There is no energy level 1.8 eV lower than the first excited state.
Therefore it can absorb a 1.8 eV photon, but not emit one.

Question 737 (2014 Q22b, 3m, 40%)

The energy of the photons emitted from the excited mercury atom can be:
10.4 – 9.8 = 0.6 eV
10.4 – x,
9.8 – x
9.8 – 6.7 = 3.1 eV
x – 6.7,
and 6.7 – 4.9 = 1.8 eV.

The missing values are either 0.9, 1.5 or 2.2 eV.

10.4 – x will be 0.6 larger than 9.8 – x.
∴ 10.4 – x = 1.5 and 9.8 – x = 0.9
∴ x = 8.9 eV.
∴ x – 6.7 – 8.9 – 6.7 = 2.2 eV.
∴ 8.9 eV (ANS)

Question 738 (2014 Q23a, 2m, 60%)

Use $\lambda = \frac{h}{p} = \frac{h}{mv}$

$\therefore \lambda = \frac{6.63 \times 10^{-34}}{9.1 \times 10^{-31} \times 2 \times 10^{6}}$

$\therefore \lambda = 3.64 \times 10^{-10}$

$\therefore$ **λ = 0.36 nm (ANS)**

Question 739 (2014 Q23b, 3m, 37%)

Electrons orbiting a nucleus can be modelled as circular standing waves, therefore the electron is exhibiting wave like properties.
The standing wave will exist only if the circumference of its orbit corresponds to a whole number of wavelengths.
i.e. $2\pi r = n\lambda$.
Therefore only specific values of wavelength are permitted. The momentum of the electron is related to its wavelength, and the energy of the electron is related to its momentum. Therefore the electron's energy is quantised.
