Mark schemes

Q1.

(a) (V =) 6.7 (V) ✓

1

(b) Max 2 from ✓✓

- Converts 6.7 eV to 1.07(2) × 10^{-18} (J)

  OR (E =) 6.7 × 1.6 × 10^{-19} seen

- Use of $E = \frac{hc}{\lambda}$

  OR

  Use of $E = hf$ **and** $c = f\lambda$

  $\lambda = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{their\ E}$

  OR

- $\lambda = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{6.7}$

(λ =) 1.9 × 10^{-7} (m) ✓

2nd bullet point, Use of:

by correct rearrangement to make λ
Or
substitution of all terms with maximum of one POT error.

3rd bullet point:

Allow their E = 4.1875 × 10^{19} without supporting working seen

Using 6.7 as their E yields an answer = 2.97 × 10^{-26} (m)

Calculator displays: 1.8554104480 × 10^{-7} (m)

3

(c) Idea that a transfer of energy to atomic electron causes transition from ground state to **B**✓

*Accept an arrow drawn from ground state to **B**.*

Idea of atomic electron moves from **B** to **A** and (visible) photon is emitted✓

*Accept an arrow drawn from **B** to **A** and statement that this is the transition where visible photon is emitted or only arrow drawn for relaxation.*

Reason for ground state to **B**, 1 from✓

- 18.4 eV is equal to energy difference between the levels.
- -21.56 + 18.4(0) = -3.16 seen
- 21.56 - 3.16 = 18.4(0) seen.
- -3.16 - -21.56 = 18.4(0) seen
- 21.56 - 18.4(0) =3.16 seen

Reason for **B** to **A,** 1 from✓

- energy difference (between **B** and **A**) is 1.8 eV and this is less than 6.7 eV (and therefore will emit a longer wavelength photon)
- other transitions (**B** to ground or **A** to ground) are too big, and wavelength is too small for visible light.
- *calculates wavelength for 1.8 eV* $\lambda = (\frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{2.88 \times 10^{-19}}) = 6.9(1) \times 10^{-7}(m)$ and states this is in visible range✓

*Reason for **B** to ground:*

Do not credit use of 18.4 eV:

- *leads to 67.5 nm (not visible)*
- *more energy than 6.7 eV (uv)*

Where no other mark is scored

Max 1 compensation mark for:

Atom in its ground state absorbs energy and electron moves up energy level.

OR

Atom de-excites and electron moves down energy level an emits a photon✓

4

[8]

Q2.

(a) An electron in the beam collides with an electron in the gas particle.

OR

An electron in the beam transfers (some of its kinetic) energy to an electron in the gas particle ✓

MP1 is awarded for the description of the electron-electron interaction or the resulting energy transfer between these electrons.

Treat the gas particles are 'excited' as neutral, must mention an interaction between beam electron and (atomic) electron or an energy transfer from beam electron to (atomic) electron as cause of excitation

Allow beam electron collides with / transfers energy to gas (particle) causing an atomic electron to gain energy

Condone use of plurals in MP1

One (atomic) electron leaves the gas particle ✓

Penalise more than one electron leaving a gas particle

Condone

***One** (atomic) electron leaves the gas (atom)/ the gas (particle) has lost **one** electron*

Physics errors that relate the effect to annihilation or beta decay or PEE or electron capture gain zero marks.

2

(b) Finds the nucleon number of the more massive isotope:

162 ÷ 2 = 81

*Alternative for **MP1**:*

Subtracts proton number from their nucleon number / subtracts total number of protons from total number of nucleons.

eg 80 − 35 or 79 – 35 or 160 – 70 or 158− 70

Condone 45 or 44 on answer line without working for one mark.

*Do **not** allow 162 − 35 or 160 − 35 or 158− 35*

OR

162 − (2 × 35) = 92 ✓

Condone 92 on answer line without working for 1 mark.

90 or 88 on answer line without working no marks

(answer =) 46 ✓ c.a.o

2

(c) The percentage is the same for both isotopes / each isotope makes up 50% of the gas (by number) ✓

Do not allow 50% of 158 and 50% of 162

Where percentage stated must be 50 %

Do not allow more than 2 isotopes

158 is made of two atoms of the lighter isotope and 162 is made of two atoms of the heavier isotope and the percentages of 158 and 162 are: both 25% / both same / present in the same ratio.

OR

Half of the 160 is made from the lighter isotope and all of the 158 is made from the lighter isotope (totalling 50%)

Or words to that effect

OR

Half of the 160 is made from the heavier isotope and all of the 162 is made from the heavier isotope (totalling 50%) ✓

Accept equivalent discussion in terms of numbers of neutrons present in nuclei in molecules / nucleon numbers of nuclei in molecules.

Restating the percentages of the molecules is insufficient for MP2.

2

[6]

Q3.

(a) **The mark scheme gives some guidance as to what statements are expected to be seen in a 1- or 2-mark (L1), 3- or 4-mark (L2) and 5- or 6-mark (L3) answer. Guidance provided in section 3.10 of the 'Mark Scheme Instructions' document should be used to assist marking this question.**

	Criteria
6	All three areas (as outlined alongside) covered with at least two aspects covered in some detail. 6 marks can be awarded even if there is an error and/or parts of one aspect missing.
5	A fair attempt to analyse all three areas. If there are several errors or missing parts then 5 marks should be awarded.
4	Two areas successfully discussed, or one discussed and two others covered partially. Whilst there will be gaps, there should only be an occasional error.
3	One area discussed and one discussed partially, or all three covered partially. There are likely to be several errors and omissions in the discussion.
2	Only one area discussed or makes a partial attempt at two areas.
1	One of the three areas covered without significant error.
0	No relevant analysis.

The following statements are likely to be present.

Area A
Loses its charge:
- Emission of electrons from the surface (when electromagnetic radiation is incident on plate) (A).
- Number of surplus electrons remaining on plate decreases with time / (photo)electrons carry away negative charge(B).

Area B
Frequency:
- **Minimum energy** required /work function. (C)
- A photon must supply this energy in one interaction. (D)
- The energy of a photon is directly proportional to its frequency / $E = hf$. (E)
- Minimum frequency is the threshold frequency. (F)

Area C
Intensity:
- Increased intensity (at same frequency) results in more photons per second incident on plate. (G)
- Must increase the number of photons (per second) even if frequency increases. (H)
- More electrons released from plate every second so loses charge more rapidly. (I)

6

(b) Use of $E = hf$ or converts their photon energy in J to eV / converts 1.1 (eV) to 1.76×10^{-19} (J)✓

For use of $E = hf$:

$6.63 \times 10^{-34} \times 1.2 \times 10^{15}$ / 7.956×10^{-19} (J) / 4.97 eV seen

MP2:

rearrangement of terms is insufficient.

Correct substitution in eV or J with or without rearrangement (condone one consistent POT error)

Use of $hf = \Phi + E_{k(max)}$ ✓

Expect to see

(Φ =) 4.97 − 1.1 / Φ + 1.1 = 4.97 /

(Φ =) 7.956 × 10^{-19} − 1.76 × 10^{-19}

/ (Φ =) 6.196 × 10^{-19} / Φ + 1.76 × 10^{-19} = 7.956 × 10^{-19}

*Condone **one** error in either hf or $Ek_{(max)}$ or signs but must be rearranged where Φ would be subject.*

Common error seen in $Ek_{(max)}$ = 6.875 × 10^{18}

Examples:

(Φ =) 7.956 × 10^{-19} − 1.1 (= − 1.1) /

(Φ =) 6.63 × 10^{-34} × 1.2 × 10^{15} − 1.1 /

(Φ =) 4.97 − 1.76 × 10^{-19} (= 4.97)

Condone error in

Accept a correctly rounded answer to 2 or more significant figure.

Condone answer (with working seen) = 6.1 or 6.07 for 2 marks.

Φ = 3.9 (eV) ✓

(Calculator displays 3.8725)

3

[9]

Q4.

(a) **Q ✓**

*Talk out of **Q** where diffraction linked to any other location (positive plate or screen)*

Diffraction as the electron move between the layers in the graphite/ electrons spread out as they move between the layers in the graphite ✓

Accept gaps between (graphite) atoms acts as slits for electrons to diffract through.

Graphite acts like a diffraction grating is not enough.

Talk out where particle property is used to describe interaction between the electrons and the graphite (e.g. electrons repelled by graphite).

*Treat interference at **R** as neutral.*

*Treat interference at **Q** as neutral.*

*Allow maximum of one mark for describing particle behaviour at **P** or **R** with a reason given:*

*- acceleration is a particle phenomenon (**P**)*

*- fluorescence is due to a collision with atomic electron which is particle phenomenon. (**R**)*

2

(b) decreases (associated) wavelength / Momentum of electrons increases ✓

Treat double slit formula as neutral

MP1 and MP2: talk out on use of wave equation / talk out on frequency remaining constant / talk out on frequency increases

quotes $\lambda = \frac{h}{mv}$ / wavelength is inversely proportional to speed / wavelength is inversely proportional to momentum ✓

less diffraction because shorter wavelength relative to the spacing between layers in the graphite / less diffraction because shorter wavelength relative to gaps (in graphite target) ✓

Accept: less diffraction because shorter wavelength relative to size of slits

Where no other mark is scored allow 1 mark for:

less diffraction ✓

'Spreads out less' is insufficient here

3

[5]

Q5.

(a) $^{4}_{2}\alpha$ ✓ + $^{234}_{90}\text{Th}$ ✓

1 mark each for alpha and Th; numbers must be correct

Must see "+" for full marks

Condone He for alpha

If no other mark is given, one mark can be awarded if He-3 is used and A and Z are correct

MAX 1 for extra particles but condone "+ $2e^{(-)}$" (not 2β)

Ignore symbol that is used for Thorium

2

(b) Idea that a neutron changes to proton/beta minus decay ✓

The particle is W- because

For MP1 condone "down quark changes to up quark".

Evidence for MP1 can be found in the form of equations or diagrams.

This is a weak interaction / it involves the weak force / there is a quark change

and indication that charge is conserved ✓

Second mark requires some explanation of why particle is negative.

MAX 1 for a complete consistent inverse interaction leading to W^{+}.

2

(c) (*FOR*:)

Lines **C** is in (both) hydrogen (and helium spectra)

OR

Line **E** is in (both) sodium (and helium spectra) ✓

(*AGAINST*:)

Line **D** is missing (is in neither the hydrogen nor the sodium spectra) ✓

*Treat references to **A**, **B** and **F** in FOR or AGAINST as neutral.*

Must link line to an element

Ignore any discussion of any "missing" lines in the helium spectrum.

*Condone use of 390 / 440 / 490 / 505 / 590 / 670 (nm) for **A/B/C/D/E/F***

Condone emission for absorption

2

(d) Wavelength = 580 nm to 590 nm ✓

Use of $E = hc/$(their wavelength) ✓

Conversion of their E in J to eV ✓

Expect to see answer in range 2.11 to 2.14 (eV)

When an energy difference between two spectral wavelengths is correctly calculated, only MP2 and MP3 can be scored.

3

(e) Photon is energy carrier OWTTE ✓

In absorption atom becomes excited/moves to higher energy state/level (by absorbing photon) ✓

In emission atom de-excited/moves to lower energy state (by emitting photon) ✓

Treat discussion of any other irrelevant phenomenon or incorrect physics as talk out in that marking point.

Allow "energy shell" but not "shell".

Condone electron for atom.

Suggestions that limit transitions to/from ground state penalise in either MP2 or MP3 once only.

Condone omission of reference to energy states/levels in either MP2 or MP3 but not both.

3

[12]