Arrangement of Electrons in the Atom

Question 1 (2016 - Section b - Question 4)

(*a*) (*i*) DISTING: *ground state:* **n = 1 / lowest (first, nearest nucleus) energy** level **/ 1*s* / minimum amount of energy / stable** state //

excited states: **n > 1 / n = 2, 3,** etc **/ n = 2, etc / 2*s*,** 2*p*, **3s, etc / n = 2 and higher / energies (energy levels) other than n = 1 / higher energies / higher energy (unstable) levels** (2 × 3)

[For excited states accept 'any (a, some) higher energy level' but not '*the* higher energy level'.]

[Allow a diagram with three concentric circles around a nucleus, with the innermost circle labelled ground state for (6).]

(*ii*) HOW: add **heat {energy, electricity, light, electromagnetic radiation}** (3)

(*iii*) EXPLAIN: [Information must be given verbally.]
excited **electron falls** back **from n = 3, 4,** etc / excited **electron falls** back **from n = 3, etc** / excited **electron falls** back **from n > 2 ($E_{n>2}$)** /
excited **electron falls from higher energy levels** //

to second shell (energy level) / to n = 2 / to E_2 //

the energy lost is **emitted as light {electromagnetic radiation (energy)} of different frequencies (colours, wavelengths)** / the energy lost is **emitted as different (discrete) *hf* (*hν*, photon(s)) / different electron transitions correspond to different lines (colours, frequencies)** (3 × 3)

[Allow two *correct* examples of Balmer series electron energy changes, e.g. $E_3 - E_2$ and $E_6 - E_2$, for the first two points.]

WHAT: **Balmer** series (3)

(*iv*) EXPLAIN: **no corresponding electron transition (energy loss) / no corresponding excited state / electron cannot exist (be) between** energy **levels / electron cannot exist (be) between** n = **3 and** n = **4** /
electron transition cannot originate from (terminate) between energy **levels / electron transition cannot originate from between** n = **3 and** n = **4 / electron transition cannot terminate between** n = **3 and** n = **2** /
$E_n - E_2 \neq hf\ (h\nu)$ for yellow **/ no whole (natural, integer) number solution for n in** $E_n - E_2 = hf\ (h\nu)$ for yellow (3)

(*b*) DESCRIBE: (3 × 3)

Method 1	Method 2	Method 3	
clean a **platinum (nichrome) wire* (rod, probe) in concentrated hydrochloric acid (HCl)**	**soak wood (splint, stick)** overnight in water / **use damp (wet) wood (splint, stick)**	**prepare** a solution of the given **salt in water and ethanol (propanol)**	(3)
dip rod in salt and hold salt in hot (blue) part of Bunsen **flame**	**dip splint (stick) in salt and hold** salt in hot (blue) part of Bunsen **flame**	**spray** solution **onto (into)** hot (blue) part of Bunsen **flame**	(3)
red (crimson) colour is a positive result for lithium	**red (crimson)** colour is a positive result for lithium	**red (crimson)** colour is a positive result for lithium	(3)

*[Allow 'inoculating loop', or 'spatula' for 'platinum wire'.]
[Clear labelled diagram for some or all points acceptable.]

(*c*) DEFINE: **space (volume, region)** around nucleus of an atom //
where an electron is likely to be found / where there is a relatively **high probability (possibility) of finding an electron**
['Area' around nucleus not acceptable.]

or

approximate **solution** //
to a **Schrödinger** wave **equation** (2 × 3)

DISTGINGUISH: **2*p* sublevel consists (is made up) of** three 2*p* **orbitals** of equal energy /
2*p* sublevel accommodates (has, holds) no more than **6 electrons** but each of the 2*p* **orbital**s **accommodates {has, holds}** no more than **2** of these **electrons** (3)

WRITE: $\mathbf{1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2}$ **(4)**
[*Allow subscripts instead of superscripts.*]
[*Arrows to represent numbers of electrons acceptable but sublevel symbols must be given.*]

EXPLAIN: **4*s*** sublevel **lower in energy than the 3*d* / electrons fill the 4*s*** sublevel **before the 3*d*** **(4)**

Question 2 (2015 - Section B - Question 5 - Part d - f)

(*d*) EXPLAIN: **in the ground state the** hydrogen **electron occupies the lowest** available **energy level** //

the electron can jump (move, become excited) to a higher energy **level (state) if it receives (absorbs)** a certain amount of **energy (light, heat, electricity, a photon)** //

excited (higher energy) **state unstable (temporary)** //

electron falls back to a lower level ANY THREE: (3 × 3)

energy emitted (given out) as photon (light of definite frequency, light of definite wavelength, hf, $h\upsilon$) thus giving rise to a spectrum /

energy emitted (hf, $h\upsilon$) corresponds to (=) difference between the **two energy levels** **($E_2 - E_1$)** thus giving rise to a line on the spectrum / $E_2 - E_1 = hf\ (h\upsilon)$ (3)
[Marks not awarded wherever *'atom'* is incorrectly used instead of *'electron'*.]
[Some marks, maximum (6), available from a good labelled diagram.]

(*e*) SUGGEST: **copper** [*'Barium'* or *'boron'* acceptable.] (3)

(*f*) WRITE: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$ / $[Ar]4s^2$ **(5)**
[*Subscripts instead of superscripts acceptable.*]
[*Arrows to represent numbers of electrons acceptable but orbital symbols must be given.*]

GIVE: **energy (distance to nucleus) of 2*s*** electron **less** than 3*s*/
nuclear attraction for 2*s* electron **greater** than 3*s* /
2s electron **less shielded (screened)** than 3*s* from nucleus /
energy for ionisation (removal of electron) of (from) 2*s* greater than for 3*s* /
probability distribution (volume, size) of 2*s* less than 3*s* **(3)**
[Corresponding statements given with regard to **3*s*** are equally acceptable.]

Question 3 (2014 - Section B - Question 5 - Part (a))

(*a*) NAME: **Bohr** **(5)**

DISTING: *energy level*: **discrete (fixed, restricted, definite, specific) energy of electron** in an atom / **energy of electron in orbit (shell, level) /** **orbit (shell, level) which electrons of equal energy** can **occupy** (3)

atomic orbital: **region (space, volume** *but not 'area' or 'place'*) around the nucleus **//**

where there is a high probability of finding an electron / where an electron is most **likely to be found / where the probability (possibility) of finding an electron is 95% (or greater)** (2 × 3)

or

space occupied by electron //
described by approximate **solution of Schrödinger equation** (2 × 3)

WRITE: $\mathbf{1s^2\,2s^2\,2p_x^{\,2}\,2p_y^{\,2}\,2p_z^{\,2}\,3s^2\,3p_x^{\,1}\,3p_y^{\,1}}$ /

1*s*	2*s*	2*p*			3*s*	3*p*	
↓↑	↓↑	↓↑	↓↑	↓↑	↓↑	↓	↓

(6)

or

$\mathbf{1s^2\,2s^2\,2p^6\,3s^2\,3p^2}$ (3)
distribution of electrons in 2*p* and 3*p* clearly shown:

2*p*			3*p*	
↓↑	↓↑	↓↑	↓	↓

(3)

[Accept dots or crosses or other as indicator of electron distribution.]

HENCE: (*i*) **3 //**

(*ii*) **8** (2 × 3)

Question 4 (2013 - Section B - Question 4 - Part (a))

(*a*) WRITE: $\mathbf{1s^2 2s^2 2p^6}$ //
$\mathbf{3s^2 3p^6 3d^{10} 4s^2}$ / $\mathbf{3s^2 3p^6 4s^2 3d^{10}}$ (2 × 3)
[Accept $p_x^{\,2} p_y^{\,2} p_z^{\,2}$ *for* p^6*. Allow with subscripts.]*
[Allow (3) for $p_x{}^2{}_y{}^2{}_z{}^2$ *but otherwise correct][Allow* ***Ar*** *instead of* $\mathbf{1s^2 2s^2 2p^6 3s^2 3p^6}$*.]*

Question 5 (2012 - Section B - Question 4 - Part (a))

(a) STATE: *(i)* **5**, *(ii)* **9** (2 × 3)

Question 6 (2010 - Section B - Question 4 - Part (a))

(a) WRITE: $\mathbf{1s^2, 2s^2, 2p^6}$ / $\mathbf{[1s^2, 2s^2, 2p^6]^{2-}}$ / **[He]**, $\mathbf{2s^2, 2p^6}$ [*commas not essential*] (6)

Question 7 (2010 - Section B - Question 5)

(a) STATE: **Small // indivisible // identical** atomic mass (weight) for particular element (2 × 4)

(b) NAME: (i): **Thomson //**
(ii): **Rutherford //**
(iii): **Millikan** (3 × 3)

(c) OUTLINE: **The electron** in a hydrogen atom **occupies (restricted to) fixed energy levels (energy values, discrete energies) //**

an electron in an energy level does not radiate energy //

electron occupies lowest energy levels available / electron occupies ground state //

the electron can move (become excited) to a higher energy **level if it receives** an amount of **energy (photon** of energy) **//**

the photon (energy) must be exactly **equal to the energy difference between the ground state (a lower level) and a higher** energy **level (excited state) //**

the electron in an excited state (a higher level) is unstable //

the excited **electron falls back to a lower** energy **level //**

emitting the excess **energy in the form of a photon of light (h*f*) / emitting light of a definite frequency (wavelength) /** emitting light according to $E_2 - E_1 = hf$ (hν)
[Accept 'quantum' for 'photon' and 'shell' for 'level.'] ANY FOUR: (6 + 3 × 3)

(d) STATE: **Didn't work for higher elements / only worked for hydrogen / doesn't work for multi electron systems //**

Did not take wave-particle duality into account //

Did not allow for uncertainty (probability) //

Did not explain higher resolution spectra / didn't explain discovery of sublevels //

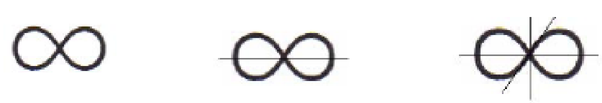
Could not account for the existence of orbitals / Zeeman effect / splitting of spectral lines (ANY 2 × 3)

(e) DEFINE: **Region (space)** around the nucleus of an atom **//**
where there is a 99% (high) probability of finding an electron / where electron most **likely to be found //**

or

space occupied by electron // described by solution of Schrödinger equation
(2 × 3)

DRAW: **Dumbbell drawn** (3)



STATE: **two / 2** (3)

Question 8 (2009 - Section B - Question 4 - Part (c))

(c) STATE: **not possible to measure the** exact **position (location) and momentum (energy, velocity) of electron** (3)
in atom **simultaneously (at same time)** (3)

Question 9 (2009 - Section A - Question 3)

(a) DESCRIBE: Introduce **salt into (on, in) flame** of bunsen burner (2)
using **platinum (nichrome) wire (probe)** / using **soaked (dipped) splint** (lollipop **stick**)* (3)
sodium (Na) gives orange (yellow) flame (3)
potassium (K) gives lilac (violet, purple****)** flame *[**Do not allow 'red' or 'pink']* (3)
*[*Allow "inoculating loop" or "spatula"]*

(b) WHICH: **KCl / potassium chloride** / the **chloride (Cl^-)** / *[Not "chlorine ion"]* (3)

WHAT: **white precipitate (ppt)** soluble in ammonia solution (3)

(c) OTHER: **iron(II) sulfate / ferrous sulfate / $FeSO_4$** solution (3)

WHICH: **KNO_3 / potassium nitrate** / the **nitrate** ion **(NO_3^-)** (3)

(d) DESCRIBE: To salt solution add ammonium **molybdate [$(NH_4)_6Mo_7O_{24}$.$4H_2O$, $(NH_4)_2MoO_4$]** solution (3)
and a few drops of concentrated **nitric acid** and warm gently (3)
yellow precipitate (ppt) formed (3)
[The (3)s for molybdate *and* nitric acid *may be awarded in either order, but the (3) for* yellow precipitate *only to be awarded when* molybdate *and/or* nitric acid *do not come after it.]*

(e) WRITE: $Na_2SO_3(.7H_2O) + BaCl_2 \rightarrow BaSO_3 + 2NaCl\ (+ 7H_2O)$ /

$Na_2SO_4(.10H_2O) + BaCl_2 \rightarrow BaSO_4 + 2NaCl\ (+ 10H_2O)$ /

$SO_3^{2-} + Ba^{2+} \rightarrow BaSO_3$ / $SO_4^{2-} + Ba^{2+} \rightarrow BaSO_4$ FORMULAS (3) BALANCING (3)

[Accept $BaSO_3.7H_2O$ *&* $BaSO_4.10H_2O$ *on the right. If water molecules on left but not on right, give (3) only – for formulas. Accept a mixture of ions and full formulas, if correct.]*

(f) SUGGEST: add dilute **acid** (3)
carbon dioxide (CO_2) evolved / **gas turns limewater milky** (3)
OR
add **magnesium sulfate ($MgSO_4$)** solution (3)
no precipitate (ppt) observed (3)

[If none of these marks are given allow (3) for identifying $NaHCO_3$,, HCO_3^-]