1. This question is about atomic spectra and energy levels.

Diagram 1 below shows part of the emission line spectrum of atomic hydrogen. The wavelengths of the principal lines in the visible region of the spectrum are shown.

Diagram 2 shows some of the principal energy levels of atomic hydrogen.

(a) Name the spectral series shown in diagram 1.

Bomb Series

………. (1)

(b) Show, by calculation, that the energy of a photon of red light of wavelength 656 nm is 1.9 eV.

....

....

....

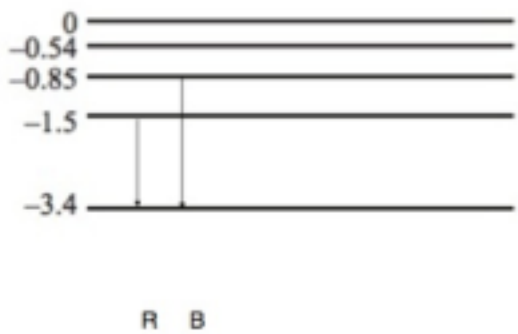
(3)

(b) On diagram 2, draw arrows to represent

(i) the electron transition that gives rise to the red line (label this arrow R). **(1)**

(ii) a possible electron transition that gives rise to the blue line (label this arrow B). **(1)**

Diagram 2



(Total 6 marks)

2. This question is about the radioactive decay of potassium-40.

A nucleus of the nuclide K (potassium-40) decays to a stable nucleus of the nuclide Ar (argon-40).

(a) State the names of the **two** particles emitted in this decay.

$^{40}_{19}K = ^{40}_{18}Ar + ^{0}_{-1}\bar{e} + ^{0}_{0}V_e$

....

(2)

(b) A sample of the isotope potassium-40 initially contains 1.5×10^{16} atoms. On average, 16 nuclei in this sample of the isotope undergo radioactive decay every minute.

Deduce that the decay constant for potassium-40 is 1.8×10^{-17} s^{-1}.

.

$$\frac{16}{60 \times 1.5 \times 10^{16}} = 1.8 \times 10^{-17} s^{-1}$$

....

....

....

....

(3)

(c) Determine the half-life of potassium-40.

$$A = Aoe^{-kt}$$

$$In\left|\frac{1}{2}\right| = -1.8 \times 10^{-17} s^{-1}$$

$$t = 3.85 \times 10^{16} s$$

....

....

(1)

(Total 6 marks)

3. This question is about particle physics.

A neutron can decay into a proton, an electron and an antineutrino according to the reaction

$$n \boxtimes p + e +.$$

(a) Deduce the value of the electric charge of the antineutrino.

$^{1}_{0}n \rightarrow {}^{1}_{1}p + {}^{0}_{-1}e + {}^{0}_{0}\bar{\nu}_e$ ....

....

(1)

(b) State whether a proton is a baryon or a lepton.

It is a baryon , because it's made of quarks and it only has one-half spin.
………………………………………………………………………………………
………………………….

(1)

(b) State the name of the fundamental interaction (force) that is responsible for this decay.

(1)

Weak force
………………………………………………………………………………………
…………………………….

(c) State how an antineutrino differs from a neutrino.

They have opposite lepton numbers.
………………………………………………………………………………………
…………………………….

(1)
(Total 4 marks)

4. Nuclear binding energy and nuclear decay

(a) State what is meant by a *nucleon*, giving an example of two nucleons.

Nucleon is the nucleus in the atom. Exampe: neutron and proton.
………………………………………………………………………………………
…………………………..

....

....

(2)

(b) Explain what a nucleon is made of and what force holds it together. Include a description of the exchange particle that mediates the interaction between nucleons.

..It's made of Gluon and strong force brings them together. The exchange particle is gluon.
………………………………………………………………………………………
………………………

....

....

(2)

(c) Define what is meant by the *mass defect* of a nucleus.

.Mass defect is the difference between the mass of a composite particle and the sum of the masses of its parts.
………………………………………………………………………………………
……………………… .

....

....

(1)

(c) Define what is meant by the *binding energy* of a nucleus.

....

....

....

(1)

The graph below shows the variation with nucleon (mass) number of the binding energy per nucleon.

(c) Use the graph to explain why energy can be released in both the fission and the fusion processes.

Because they can be gather together by high binding energy, and in fission and fusion processes, there are high binding energy. While gathering them together, energies are released.

……..

....

....

....

(3)

(c) Use the graph to explain why there is an abundance of iron (Fe) in the universe.

Because it has the highest binding energy and it is the most stable.

……..

....

....

....

....

(2)

(d) A sample of carbon-11 has an initial mass of 4.0×10^{-15} kg. Carbon-11 has a half-life of approximately 20 minutes. Calculate the mass of carbon-11 remaining after one hour has elapsed.

....

....

....

(2)

(e) Uranium-238, undergoes α-decay to form an isotope of thorium. Write down the nuclear equation for this decay.

$^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}\alpha$

....

....

(2)
(Total 11 marks)

5. This question is about a proton.

The proton is made out of three quarks.

(a) Explain why the three quarks in the proton do not violate the Pauli exclusion principle.

The two upper quark has opposite direction, and thus they cancel each other.
……..

(2)

(b) Quarks have spin Explain how it is possible for the proton to also have spin

The remaining quark is the bottom quark, and it has either a positive or negative one half spin .
……..

....

(2)
(Total 4 marks)

6. Which **one** of the following correctly gives the number of electrons, protons and neutrons in a neutral atom of the nuclide ?

	Number of electrons	**Number of protons**	**Number of neutrons**
A.	65	29	36
B.	36	36	29
C.	29	29	65
D.	29	29	36

(1)

7. The unified mass unit is defined as

A. the mass of one neutral atom of C.

B. of the mass of one neutral atom of C.

C. of the mass of one neutral atom of C.

D. the mass of the nucleus of C.

(1)

A 8. Which of the following provides evidence for the existence of atomic energy levels?

A. The absorption line spectra of gases

B. The existence of isotopes of elements

C. Energy release during fission reactions

D. The scattering of α -particles by a thin metal film

(1)