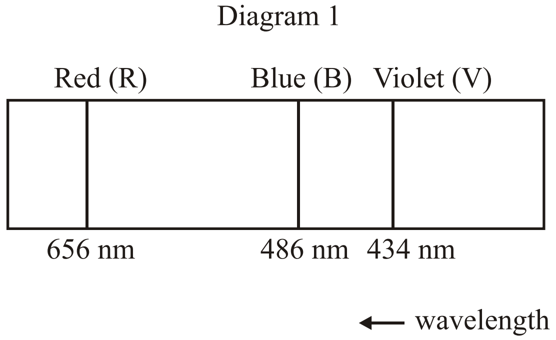
Midterm Correction

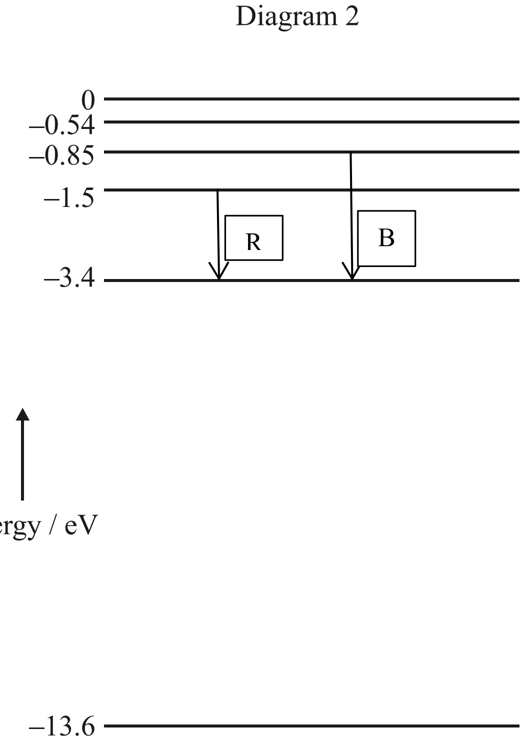
Nam : Fung Cho Mau

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.

Balmer Series (1)

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

$$E = \frac{hc}{\lambda} = \frac{1.24 \times 10^{-6}}{656 \times 10^{-9}} = 1.9ev$$ **(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)
(Total 6 marks)

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

A nucleus of the nuclide $^{40}_{19}$K (potassium-40) decays to a stable nucleus of the nuclide $^{40}_{18}$Ar (argon-40).

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

$$^{40}_{19}K = ^{40}_{18}Ar + ^{0}_{1}e + V$$ **(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}.

$$\frac{16}{1.5 \times 10^{16}} \div 60 = 1.8 \times 10^{-17}$$ **(3)**

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

$$T_{\frac{1}{2}} = \frac{In2}{\lambda} = \frac{0.69}{1.8 \times 10^{-19}} = 3.83 \times 10^{16}$$

(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

$$n \rightarrow p + e + \bar{v}_e .$$

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

Zero **(1)**

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

.

(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.

Neutrino has a left spin-direction while Antineutrino has a right spin-direction.

(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.

(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.

Nucleons are made of protons and neutrons and gluon holds it together.

Gluon is a kind of force interaction that stick these particles together like glue.

(2)

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

Mass defect is when the neclues are declaying, they will loose power and mass **(1)**

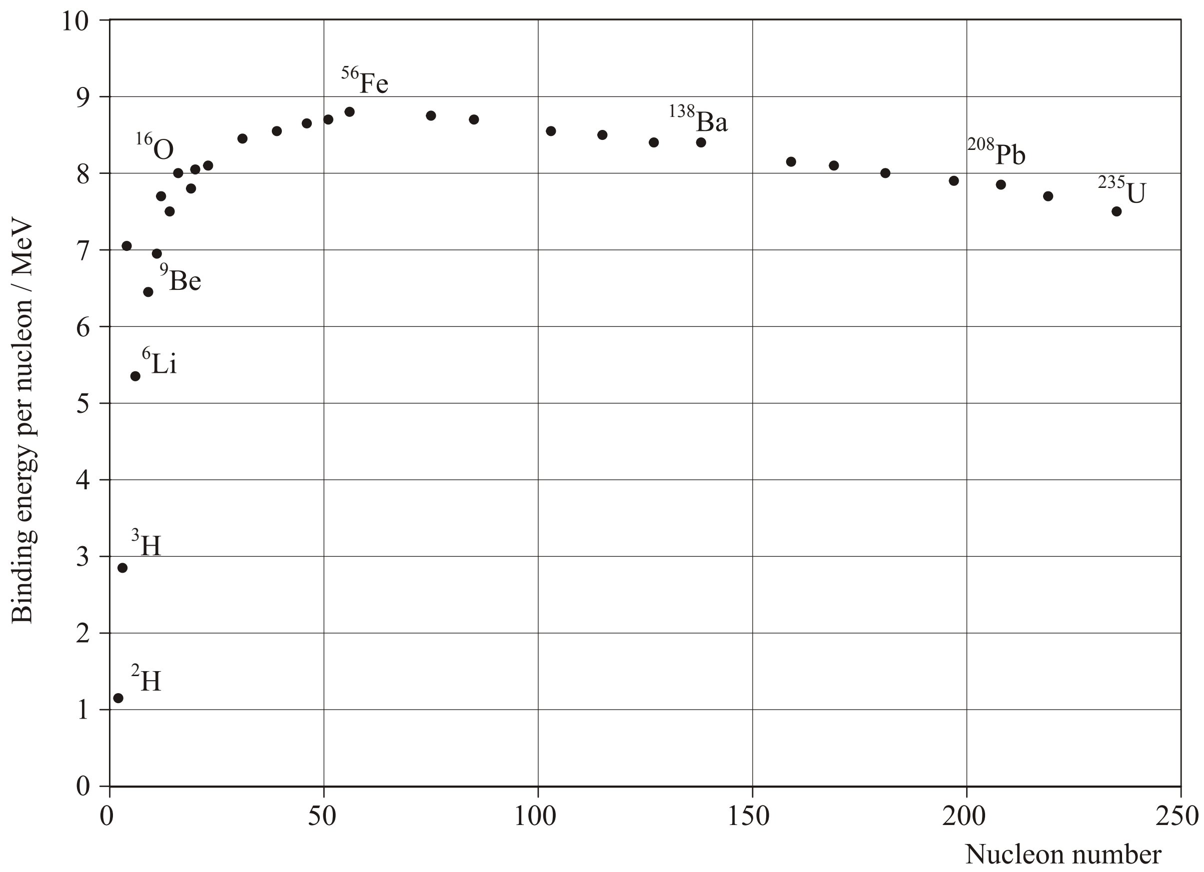
(d) Define what is meant by the *binding energy* of a nucleus.

Binding energy is the energy it used during the decay process.

(1)

(In this part of the exam I got them all right, so no corrections have to be made.)

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.

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(3)

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

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(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.

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....

....

(2)

(e) Uranium-238, $^{238}_{92}\text{U}$, undergoes α-decay to form an isotope of thorium. Write down the nuclear equation for this decay.

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(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 three quarks in the proton is not in the same location, and two of the quarks are spinning upwards compare to different direction of other quark.

(2)

(b) Quarks have spin $\frac{1}{2}$. Explain how it is possible for the proton to also have spin $\frac{1}{2}$.

When the three quarks connect to each other, and then have spin1/2 in the same direction. Because proton can have a spin of 1/2. .

(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 $^{65}_{29}\text{Cu}$?

	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 $^{12}_{6}\text{C}$.

B. $\frac{1}{12}$ of the mass of one neutral atom of $^{12}_{6}\text{C}$.

C. $\frac{1}{6}$ of the mass of one neutral atom of $^{12}_{6}\text{C}$.

D. the mass of the nucleus of $^{12}_{6}\text{C}$.

(1)

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)

Jackie Fung.

21/40

53%

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.

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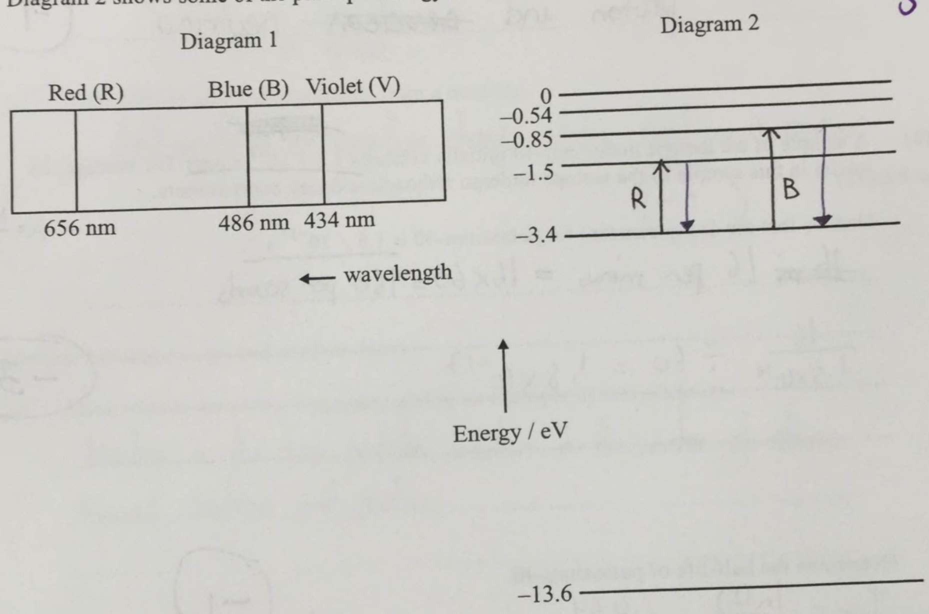


(a) Name the spectral series shown in diagram 1.

~~Bohr series~~ visible light Balmer series (1)

−1

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

$3.4 - 1.5 = 1.9$ eV

$E = \frac{hc}{\lambda}$ $\frac{1.24\times10^{-6}}{656\times10^{-9}} = 1.9$ eV

−3

(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)

−1

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

(Total 6 marks)

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

A nucleus of the nuclide $^{40}_{19}K$ (potassium-40) decays to a stable nucleus of the nuclide $^{40}_{18}Ar$ (argon-40).

$K = Ar + {}^{0}_{1}e +$ ~~ineuction~~

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

proton and ~~neucleon~~ neutrino

-1

(2)

$A = A_0 e^{t_{\frac{1}{2}}\lambda}$

(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.

~~1.5×10^{15}~~

$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

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

~~16 m~~ 16 per minus $= 16 \times 60 = 960$ per seconds

$\frac{16}{1.5\times10^{16}} \div 60 = 1.8\times10^{-17}$

-3

(3)

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

$\tau_{\frac{1}{2}} = \frac{\ln(2)}{\lambda}$ $\frac{0.69}{1.8\times10^{-17}} = 3.8\dot{3}\times10^{16}$

-1

(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

$$n \rightarrow p + e + \bar{v}_e.$$

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

Negative Zero

-1

(1)

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

Proton is a ~~lepton~~ baryon

✓

(1)

~~(b)~~ State the name of the fundamental interaction (force) that is responsible for this decay. (1)

Collision, Kinetic force —1

weak force.

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

Antinectrino is negative charge where nectrino is positive. (1)

opposite lepton —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.

Necleon is the two particles located in the center of atom

Named 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.

nuclean is made of small matters neutron and protons, the binding —2

Gluons energy keeps them together. Even though ~~neutr~~ neutron has no charge

and proton is positives, the particles interat with each other so they (2)

don't move away.

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

Mass defect of a nucleus is to decrease the number of ~~proto~~ —1

proton and neutrons.

~~Energy is stored in these~~ necleus are decay they will

loose power and mass (1)

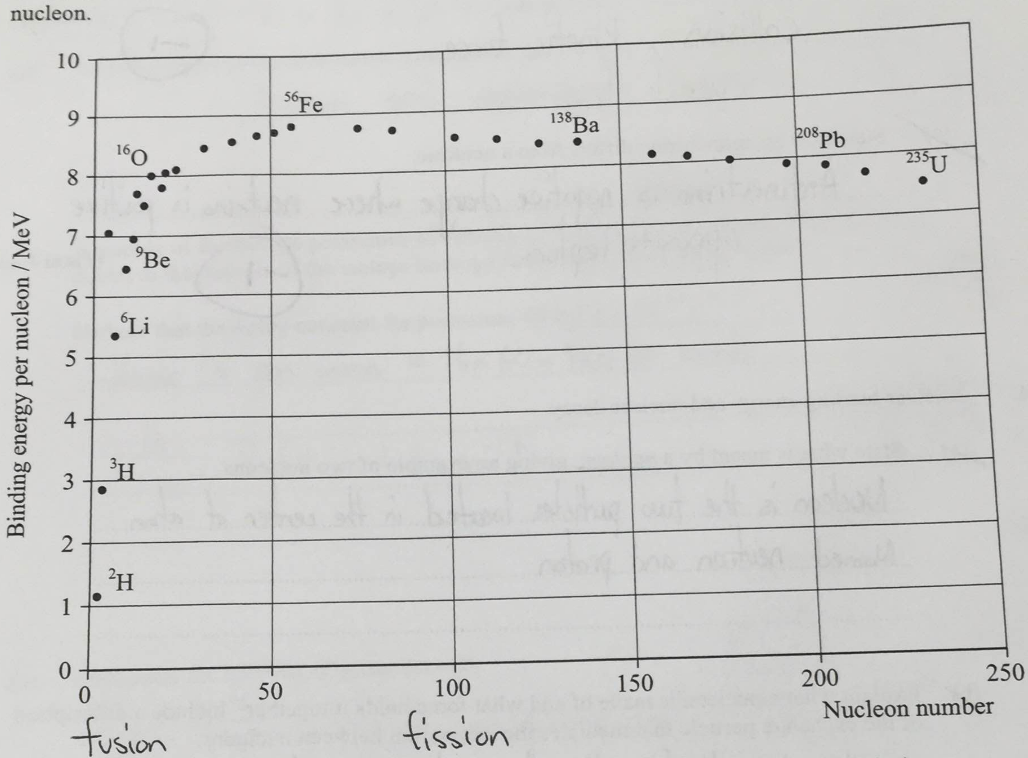
~~(e)~~ Define what is meant by the *binding energy* of a nucleus.

The force of attraction the held the neutron and protons together —1

in the nucleus.

Energy is stored in the nucleus in that assemble. (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.

From 0 to 56 in nucleon number, it is fusion, It slowly combine small particles in to a larger and reactive ~~atoms~~ elements. It contain a stronger Binding energy where from 56 to 235 is fission, It is breaking down ~~most~~ big atoms into smaller ones so it release energy. **(3)**

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

Because Fe contain the highest binding energy per nuclean, It is realitively ~~a~~ stable based on the graph, so it cannot be able to increase more energy in it. Therefore, it is very not-reative and a hard element to use. **(2)**

4

(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.

$\frac{60}{20} = 3$

$4.0 \times 10^{-15} \times \left(\frac{1}{2}\right)^3 = 5 \times 10^{-16}$ kg

(2)

(e) Uranium-238, ${}^{238}_{92}U$, undergoes α-decay ${}^{4}_{2}He$ to form an isotope of thorium. Write down the nuclear equation for this decay.

${}^{238}_{92}U = {}^{234}_{90}TH + {}^{4}_{2}He$

(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.

Because it is a femino

(2)

(b) Quarks have spin $\frac{1}{2}$. Explain how it is possible for the proton to also have spin $\frac{1}{2}$.

Proton is a atomatic sequences, It is possible for it to have $\frac{1}{2}$ spin and normal spin.

(2)

(Total 4 marks)

-3

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(1)

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(1)