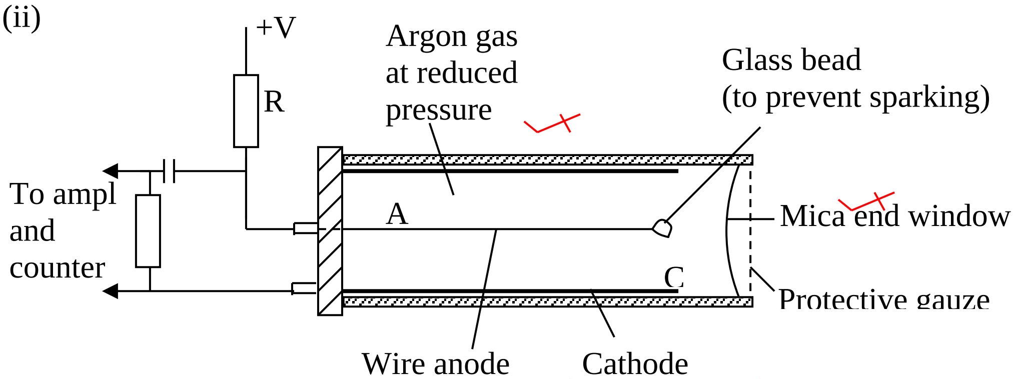
Qn	Answer	Marks
1. (a)	(i) … energy which just removes an electron completely from the atom.	1
	(ii) By convention the energy of the atom when its electron is at infinity, is regarded as zero. This would imply that work is done to move an electron towards the nucleus. But the reverse is true. Instead work is done when taking an electron away from the nucleus. So the ionization energy is negative	1 ½ ½
(b)	(i) Let the minimum velocity be v Then $\frac{1}{2}mv^2 = 10.4$ eV $\therefore \quad v = \sqrt{\frac{2\times10.4\times1.6\times10^{-19}}{9.11\times10^{-31}}}$ $= \mathbf{1.91 \times 10^{6}\ m\ s^{-1}}$	1 1 1
	(ii) Let λ = wavelength Then $\frac{hc}{\lambda} = E_3 - E_2$ $\therefore \quad \lambda = \frac{hc}{E_3 - E_2} = \frac{6.6\times10^{-34}\times3.0\times10^{8}}{-(3.7-5.5)\times1.6\times10^{-19}}$ $= \mathbf{6.875 \times 10^{-7}\ m}$	1 1 1
(c)	- The continuous spectrum is a result of the fact that many of the electrons make more than one encounter with the target atoms before losing all their energy, each encounter resulting in emission of a photon of energy. - Therefore several photons, with a range of wavelengths, are emitted leading to such a spectrum. - This spectrum has a definite minimum wavelength which results from those electrons which lose all their energy in one encounter. - Line spectra result when high-energy electrons penetrate deep into the atom and displace electrons from very deep energy levels. - The subsequent fall of an electron from a higher energy level into the vacancy results in the emission of a high-energy X-ray photon with energy characteristic of the fall involved and therefore of the target metal.	1 1 1 1 1
(d)	(i) $2d\sin\theta = n\lambda$, where n = 1 $\therefore \quad \sin\theta = \frac{\lambda}{2d} = \frac{2.0\times10^{-10}}{2\times3.1\times10^{-10}} = 0.323$ $\therefore \quad \theta = \mathbf{18.8^{o}}$	1 1
	(ii) KCl is made up of K^+ ions and Cl^- ions 1 mole of K^+ + 1 mole of Cl^- gives 1 mole of KCl Each K^+ ion or Cl^- ion occupies a volume d^3, where d is the spacing between a K^+ and a Cl^- (neighbouring)	½ ½

<table>
<tr><td></td><td>Therefore each molecule of KCl occupies a volume of $2d^3$
There are N_A molecules in one mole of a substance, where $N_A = 6.02 \times 10^{23}$
So volume of 1 mole = $2N_Ad^3$
Now density $= \dfrac{\text{Mass}}{\text{Volume}} = \dfrac{74.5\times10^{-3}}{2\times6.02\times10^{23}\times3.1^3\times10^{-30}}$
$= \mathbf{2.08 \times 10^3\ kg\ m^{-3}}$</td><td>½

½
1
1</td></tr>
<tr><td colspan="3"><i>Total = 20</i></td></tr>
<tr><td>2. (a)</td><td>(i) Half-life is the time taken for half the atoms to disintegrate.
Decay constant is the ratio of the activity to the number of radioactive nuclei present</td><td>1
1</td></tr>
<tr><td></td><td>(ii) The number of radioactive atoms present</td><td>1</td></tr>
<tr><td>(b)</td><td>(i)

α-particle	β-particle
- Positively charged	- Negatively charged
- Heavy – (relative mass 4)	- Weightless
- Less penetrating power	- Greater penetrating power

</td><td>1
1
1</td></tr>
<tr><td></td><td>(ii)



It consists of a cylindrical metal cathode C and a thin coaxial wire anode, A, containing argon at low pressure.

- The anode, A, is kept at a positive potential V e.g500V relative to the cathode, C.
- When an ionising particle enters the tube, a few electrons and ions are produced in the gas.
- If V is above the breakdown potential of the gas, the electrons gain enough energy to cause further ionisation leading to breakdown (avalanche).
- The electrons move to the anode A and the positive ions towards the cathode C.
- The current in the high resistance R produces a p.d which is amplified and passed to a counter such as scaler or ratemeter.
- Argon mixed with a halogen helps to stop the discharge quickly.

This way the G-M tube is able to detect individual passages of ionizing particles</td><td>½
½
1
½
1
1
½
½
½</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

(c)	(i) In a radioactive decay the rate of disintegration $\frac{dN}{dt}$ is directly proportional to the number of atoms, N, present at the instant. Thus $\frac{dN}{dt} = -kN$ ✓ where k is the radioactive decay constant So $\int_{N_o}^{N} \frac{dN}{N} = \int_{o}^{t} -kdt$ ✓ $\therefore \quad \ln\left(\frac{N}{N_o}\right) = -kt$ ✓ $\therefore \quad \mathbf{N = N_oe^{-kt}}$ ✓	½ ½ ½ ½
	(ii) From $\ln\left(\frac{N}{N_o}\right) = -kt$, where $N = \frac{1}{2}N_o$ and $t = T_{½}$, we have $\ln\left(\frac{\frac{1}{2}N_o}{N_o}\right) = -kT_{½}$ ✓ $\therefore \quad T_{½} = \frac{\ln 2}{k}$ ✓	1 1
(d)	The original number of radioactive atoms, $N_o = \frac{2}{60} \times 6.02 \times 10^{23}$ ✓ Original activity, $A_o = kN_o$ ✓ Now $k = \frac{\ln 2}{T_{1/2}} = \frac{\ln 2}{5.3} = 0.131 \text{ year}^{-1}$ ✓ and $A = A_oe^{-kt} = kN_oe^{-kt}$ ✓ $= 0.131 \times \frac{2}{60} \times 6.02 \times 10^{23}\ e^{-(0.131 \times 5.3)}$ ✓ $= \mathbf{1.31 \times 10^{21}}$ **per year** ✓	½ ½ ½ ½ 1 1
	Total = 20	