X-RAYS

1. (a) Minimizing energy lost due to collisions; (1mk)

(b)

Hard	Soft
1. Highly penetrative /Energy	Low penetrative /Energy
2. Short wavelength	Long wavelength
3. High frequency	Low frequency
4. Produced at high voltage	produced at low voltage

Any one x 3 = (3mks)

2. Lead. 1
Lead shields will stop the travel of X-rays. 1
X rays are dangerous/ hazardous. 1

3. (a) Rays originating from target. 1
Rays directed out of window. 1
(b) Cathode 1
(c) >10,000V (10kV) 1
(d) Electrons are boiled/ given off 1
Attracted/ accelerated towards anode 1
(e)Anode becomes warm/ hot 1
due to energy absorbed from electrons. 1
(f) Electrons would bump into / ionise/ excite gas molecules 1
Fewer electrons would reach the anode
Or
The electrons have not enough energy to make X-rays 1
(g) Lead. 1
Lead shields will stop the travel of X-rays. 1
X rays are dangerous/ hazardous. 1
TOTAL / 13

4. Appropriate voltage:

kilovolt range [Not keV] **(1)** 1

Anode rotated:

so heat spread out/not just one point **(1)** 1

Tube evacuated:

So no collisions/obstruction/scattering of electrons with air molecules
OR by atoms/particles OR equivalent **(1)** 1

Appropriate material:

Lead **(1)** 1

[4]

5. (i) thermionic emission; 1

(ii) A description to include three from:

1. heat in filament (releases electrons);
2. reference to 50 kV supply;
3. KE (due to electric field);

4. wave energy/energy of X-rays/heat; 3

(iii) (50 kV) power supply; 1
[Reject heater filament]