X-RAYS

1. (a) Minimizing energy lost due to collisions; (1mk)  
   (b) Hard  
       1. Highly penetrative /Energy  
       2. Short wavelength  
       3. High frequency  
       4. Produced at high voltage  
   Soft  
       1. Low penetrative /Energy  
       2. Long wavelength  
       3. Low frequency  
       4. 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)  
   Anode rotated:  
   so heat spread out/not just one point (1)  
   Tube evacuated:  
   So no collisions/obstruction/scattering of electrons with air molecules  
   OR by atoms/particles OR equivalent (1)  
   Appropriate material:  
   Lead (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]