**Q1.** Sodium metal has a work function of 2.28 eV. An atom of sodium has an ionisation energy of 5.15 eV.

(a) (i) State what is meant by work function.

.....

.....

**(2)**

(ii) State what is meant by ionisation energy.

.....

.....

**(2)**

(b) Show that the minimum frequency of electromagnetic radiation needed for a photon to ionise an atom of sodium is about $1.2 \times 10^{15}$ Hz.

**(2)**

(c) Electromagnetic radiation with the frequency calculated in part (b) is incident on the surface of a piece of sodium.

Calculate the maximum possible kinetic energy of an electron that is emitted when a photon of this radiation is incident on the surface.
Give your answer to an appropriate number of significant figures.

maximum kinetic energy = ..... J

**(3)**

(d) Calculate the speed of an electron that has the same de Broglie wavelength as the electromagnetic radiation in part (b).

speed = ..... m $s^{-1}$

**(3)**
**(Total 12 marks)**

**Q2.** The photoelectric effect can be demonstrated by illuminating a negatively charged plate, made from certain metals, with ultraviolet (UV) light and showing that the plate loses its charge.

(a) Explain why, when ultraviolet light is shone on a **positively** charged plate, no charge is lost by the plate.

.....

.....

.....

.....

.....

.....

.....

**(2)**

(b) Threshold frequency and work function are important ideas in the study of the photoelectric effect.

**Tables 1** and **2** summarise the work functions of three metals and photon energies of three UV light sources.

**Table 1**

| Metal | Work function / eV |
|---|---|
| Zinc | 4.3 |
| Iron | 4.5 |
| Copper | 4.7 |

**Table 2**

| Light source | Photon energy / |
|---|---|

| | eV |
|---|---|
| 1 | 4.0 |
| 2 | 4.4 |
| 3 | 5.0 |

Discuss the combinations of metal and UV light source that could best be used to demonstrate the idea of threshold frequency and the idea of work function.

.....

.....

.....

.....

.....

.....

**(6)**

(c) Calculate the maximum kinetic energy, in J, of the electrons emitted from a zinc plate when illuminated with ultraviolet light.

work function of zinc = 4.3 eV

frequency of ultraviolet light = $1.2 \times 10^{15}$ Hz

maximum kinetic energy ..... J

**(3)**

(d) Explain why your answer is a maximum.

.....

.....

.....

**(1)**
**(Total 12 marks)**

**Q3.** When comparing X-rays with UV radiation, which statement is correct?

| | | |
|---|---|---|
| **A** | X-rays have a lower frequency. | ⬭ |
| **B** | X-rays travel faster in a vacuum. | ⬭ |
| **C** | X-rays do not show diffraction and interference effects. | ⬭ |
| **D** | Using the same element, photoelectrons emitted using X-rays have the greater maximum kinetic energy. | ⬭ |

**(Total 1 mark)**

**Q4.** Monochromatic radiation from a source of light (source A) is shone on to a metallic surface and electrons are emitted from the surface. When a second source (source B) is used no electrons are emitted from the metallic surface. Which property of the radiation from source A must be greater than that from source B?

| | | |
|---|---|---|
| **A** | amplitude | ⬭ |
| **B** | frequency | ⬭ |
| **C** | intensity | ⬭ |
| **D** | wavelength | ⬭ |

**(Total 1 mark)**

**Q5.** In a photoelectric experiment, light is incident on the metal surface of a photocell. Increasing the intensity of the illumination at the surface leads to an increase in the

| | | |
|---|---|---|
| **A** | work function | ⬭ |

**B** minimum frequency at which electrons are emitted ⬭

**C** current through the photocell ⬭

**D** speed of the electrons ⬭

**(Total 1 mark)**

**Q6.** When ultraviolet light of frequency $3.0 \times 10^{15}$ Hz is incident on the surface of a metal,electrons of maximum kinetic energy $1.7 \times 10^{-18}$ J are emitted.

(a) Explain why the emitted electrons have a range of kinetic energies up to a maximum value.

.....

.....

.....

.....

.....

.....

**(3)**

(b) (i) Show that the work function of the metal is 1.8 eV.

**(3)**

(ii) Calculate the threshold frequency of the metal. Give your answer to an appropriate number of significant figures.

threshold frequency.....Hz

**(3)**

(c) (i) State and explain the effect on the emitted electrons of decreasing the frequency of the incident radiation whilst keeping the intensity constant.

.....

.....

.....

.....

**(2)**

(ii) State and explain the effect on the emitted electrons of doubling the intensity of the incident radiation whilst keeping the frequency constant.

.....

.....

.....

.....

**(2)**

**(Total 13 marks)**

**Q7.**The *work function* of sodium is 2.28 e V.

(a) State what is meant by the term work function.

.....

.....

.....

**(2)**

(b) Calculate the threshold frequency for sodium.

threshold frequency ..... Hz

**(3)**

**(Total 5 marks)**