Particle Nature of Light and The Wave-Particle Duality (MCQ Only)

Q1.

Which of the following is the SI base unit for the Planck constant?

- ☒ **A** N m^{-1} s^{-1}
- ☒ **B** N m s
- ☒ **C** kg m^2 s^{-1}
- ☒ **D** kg m^{-2} s

(Total for question = 1 mark)

Q2.

Radiation of frequency *f* and wavelength λ is emitted when an electron falls from energy level E_2 to energy level E_1.

$E_2 - E_1$ is equal to

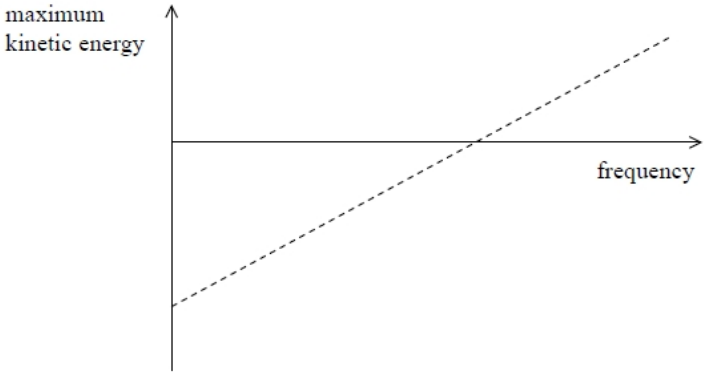
- ☒ **A** $\frac{hc}{f}$
- ☒ **B** $\frac{hc}{\lambda}$
- ☒ **C** $\frac{hf}{c}$
- ☒ **D** $\frac{h\lambda}{c}$

(Total for question = 1 mark)

Q3.

In an investigation of the photoelectric effect, a metal plate is illuminated with light of different frequencies.

The graph shows the maximum kinetic energy of emitted electrons at different frequencies.



Which line of the table correctly shows the values given by the graph?

	x intercept	negative y intercept
☐ **A**	Planck constant	work function
☐ **B**	threshold frequency	Planck constant
☐ **C**	threshold frequency	work function
☐ **D**	work function	threshold frequency

(Total for question = 1 mark)

Q4.

The image shows a diffraction pattern observed when a beam of electrons is fired at thin gold foil.

(Source: © The Reading Room/Alamy Stock Photo)

What property of electrons does this observation demonstrate?

- ☒ **A** they exist in discrete energy levels
- ☒ **B** they have a negative charge
- ☒ **C** their small mass
- ☒ **D** their wave nature

(Total for question = 1 mark)

Q5.

The photoelectric effect provides evidence for the particle nature of electromagnetic radiation.

Which of the following observations of the photoelectric effect could also be explained using the wave nature of electromagnetic radiation?

☒ **A** The emission of photoelectrons is instantaneous.

☒ **B** The maximum kinetic energy of photoelectrons depends on frequency.

☒ **C** The rate of emission of photoelectrons depends on intensity.

☒ **D** There is a minimum frequency for emission of photoelectrons to occur.

(Total for question = 1 mark)

Q6.

When light is incident on the surface of a metal, electrons may be emitted by the photoelectric effect. Observations of the photoelectric effect helped to establish that light can exhibit particle behaviour.

Which of the following observations of the photoelectric effect could also be explained by light behaving as a wave?

☒ **A** Emission of photoelectrons occurs immediately the surface is illuminated.

☒ **B** Photoelectrons are only emitted when the frequency of the light is more than a certain minimum value.

☒ **C** The maximum kinetic energy of the photoelectrons is independent of the intensity of the incident light.

☒ **D** When the intensity of the incident light increases, photoelectrons are emitted at a greater rate.

(Total for question = 1 mark)

Q7.

Which of the following provides evidence for the particle model of electromagnetic radiation?

- ☒ **A** diffraction
- ☒ **B** interference
- ☒ **C** polarisation
- ☒ **D** visible line spectra

(Total for question = 1 mark)

Q8.

When monochromatic light is incident on the surface of a metal, electrons are emitted by the photoelectric effect.

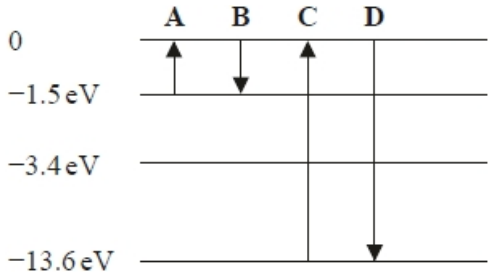
If other conditions are unchanged, the maximum kinetic energy of the electrons will be increased by

- ☒ **A** increasing the frequency of the incident light.
- ☒ **B** increasing the intensity of the incident light.
- ☒ **C** using a metal with a higher threshold frequency.
- ☒ **D** using a metal with a higher work function.

(Total for question = 1 mark)

Q9.

Some of the energy levels of an atom of a gas are shown.



During which transition, A, B, C or D, is electromagnetic radiation with the shortest wavelength emitted?

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for question = 1 mark)

Q10.

An electron travels at a velocity v.

Which of the following is the correct expression for the de Broglie wavelength λ of the electron?

☒ **A** $\lambda = \dfrac{3.00 \times 10^{8}}{9.11 \times 10^{-31} \times v}$

☒ **B** $\lambda = \dfrac{9.11 \times 10^{-31} \times v}{3.00 \times 10^{8}}$

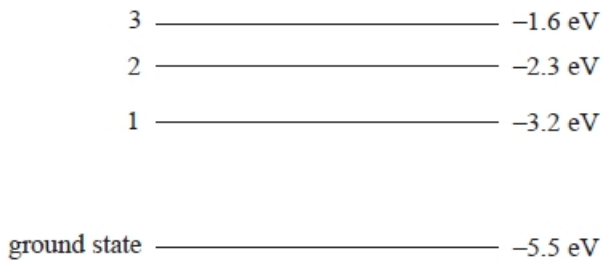
☒ **C** $\lambda = \dfrac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times v}$

☒ **D** $\lambda = \dfrac{9.11 \times 10^{-31} \times v}{6.63 \times 10^{-34}}$

(Total for question = 1 mark)

Q11.

The diagram shows the lowest energy levels for a certain atom.



A photon with energy 3.2 eV is absorbed.

An electron could move from

(1)

☒ **A** ground state to level 1.

☒ **B** ground state to level 2.

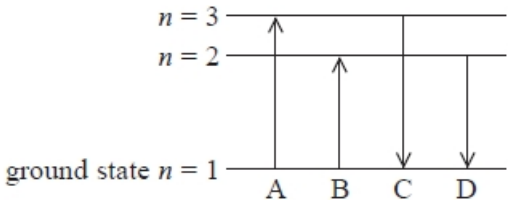
☒ **C** level 1 to ground state.

☒ **D** level 2 to ground state.

(Total for question = 1 mark)

Q12.

The energy level diagram shows four possible energy transitions for an electron in an atom.



Which arrow shows the transition made by the electron when the atom emits radiation with the longest wavelength?

☒ **A**

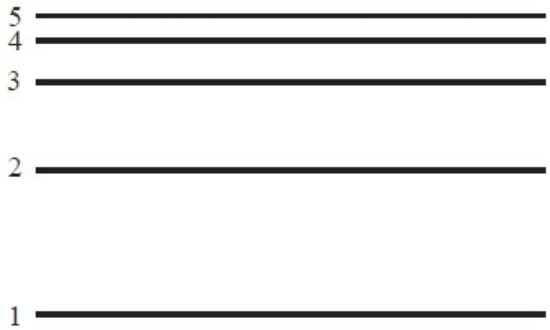
☒ **B**

☒ **C**

☒ **D**

(Total for question = 1 mark)

Q13.
The diagram shows five energy levels in an atom.



Electromagnetic radiation is incident on the atom.

Which transition would be caused by the absorption of the lowest frequency of radiation?

☒ **A** 1 to 5

☒ **B** 1 to 2

☒ **C** 4 to 5

☒ **D** 5 to 4

(Total for Question = 1 mark)

Q14.

Einstein's photoelectric equation states

$$hf = \phi + \frac{1}{2}mv^2_{max}$$

The quantity denoted by ϕ is the minimum

- ☒ **A** amount of energy of a photon needed to release an electron.
- ☒ **B** amount of energy of an electron needed to release a photon.
- ☒ **C** frequency of a photon needed to release an electron.
- ☒ **D** frequency of an electron needed to release a photon.

(Total for question = 1 mark)

Q15.

In an experiment to determine the wavelength of light, a diffraction grating is illuminated with light from a monochromatic source. A series of bright spots is observed.

The experiment is repeated and the distance between consecutive bright spots increases.

Select the row of the table that gives two changes to the experimental set up which would both cause the distance between consecutive bright spots to increase.

(1)

	Number of slits per mm in the diffraction grating	Wavelength of the light source
☐ A	Increased	Increased
☐ B	Increased	Decreased
☐ C	Decreased	Increased
☐ D	Decreased	Decreased

(Total for question = 1 mark)

Mark Scheme - Particle Nature of Light and The Wave-Particle Duality (MCQ Only)

Q1.

Question Number	Answer	Mark
	C $\quad$ **kg m^2 s^{-1}**	**1**
	Incorrect Answers: **A** – N is not an SI base unit and incorrect arrangement **B** – N is not an SI base unit **D** – incorrect arrangement	

Q2.

Question Number	Answer	Mark
	B	**1**

Q3.

Question Number	Acceptable Answers	Additional Guidance	Mark
	C		**1**

Q4.

Question Number	Answer	Mark
	D their wave nature	**1**
	Incorrect Answers: **A** not demonstrated by this observation **B** not demonstrated by this observation **C** not demonstrated by this observation	

Q5.

Question Number	Answer	Mark
	The only correct answer is C because wave nature would predict a greater emission rate with a greater incident power A because instantaneous emission is only predicted by particle nature B because dependence of maximum kinetic energy on frequency is only predicted by particle nature D because minimum frequency for emission is only predicted by particle nature	**1**

Q6.

Question Number	Acceptable answer	Additional guidance	Mark
	D	The only correct answer is **D**: a wave of greater intensity would still transfer energy at a greater rate which could release photoelectrons at a greater rate even if they could absorb energy continuously A is not correct because time would be required for absorption of sufficient wave energy B is not correct because absorption of sufficient wave energy would occur over time C is not correct because at higher intensities the waves would have higher amplitudes and energy could increase over time to higher values	1

Q7.

Question Number	Answer	Mark
	D visible line spectra	1
	Incorrect Answers: **A** – wave model **B** – wave model **C** – wave model	

Q8.

Question Number	Acceptable answers	Additional guidance	Mark
	The only correct answer is **A** because, using Einstein's photoelectric equation, $hf = \varphi + \frac{1}{2} mv^2_{max}$, since the work function is constant, an increase in frequency results in an increase in the maximum kinetic energy of the photoelectrons B is not correct because, using Einstein's photoelectric equation, $hf = \varphi + \frac{1}{2} mv^2_{max}$, intensity has no effect on the maximum kinetic energy of the photoelectrons, just the rate at which they are emitted C is not correct because , using Einstein's photoelectric equation, $hf = \varphi + \frac{1}{2} mv^2_{max}$, and since the work function is equal to (the Planck constant × threshold frequency), a higher threshold frequency will lead to a lower maximum kinetic energy of the photoelectrons D is not correct because, using Einstein's photoelectric equation, $hf = \varphi + \frac{1}{2} mv^2_{max}$, a higher work function will lead to a lower maximum kinetic energy of the photoelectrons		1

Q9.

Question Number	Answer	Mark
	D	1
	Incorrect Answers: A – absorption of the longest wavelength B – emission with the longest wavelength C – absorption of the shortest wavelength	

Q10.

Question Number	Answer	Mark
	C $\lambda = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times v}$	1
	Incorrect Answers: **A** Incorrect value for h **B** Incorrect arrangement and incorrect value for h **D** Incorrect arrangement	

Q11.

Question Number	Answer	Mark
	B ground state to level 2	**1**
	Incorrect Answers: A – incorrect change in energy C – incorrect change in energy and direction D – incorrect direction	

Q12.

Question Number	Answer	Mark
	D shortest arrow pointing to ground state	**1**
	Incorrect Answers: **A** – shortest wavelength absorbed **B** – longest wavelength absorbed **C** – shortest wavelength emitted	

Q13.

Question Number	Answer	Mark
	C	**1**

Q14.

Question Number	Answer	Mark
	A – amount of energy of a photon needed to release an electron	1
	Incorrect Answers: B- an electron does not release a photon C – reference to frequency incorrect D - reference to frequency incorrect and electron does not release a photon	

Q15.

Question Number	Answer	Mark
	A Using $n\lambda = d\sin\theta$ **Number of slits per mm in the diffraction grating** — **Increased** **Wavelength of the light source** — **Increased**	**1**
	Incorrect Answers: B – wavelength decreasing would cause *d* to decrease C – number of slits/mm decreasing would cause *d* to decrease D –both decreasing causes *d* to decrease	