

## 11: Quantum physics – Topic questions

The questions in this document have been compiled from a number of past papers, as indicated in the table below.

Use these questions to formatively assess your learners' understanding of this topic.

Question	Year	Series	Paper number
10	2017	June	41
11	2017	June	41
10	2017	March	42

The mark scheme for each question is provided at the end of the document.

10 (a) State

- (i) what is meant by the *hardness* of an X-ray beam,

.....  
.....  
.....[2]

- (ii) how the hardness of an X-ray beam from an X-ray tube is increased.

.....  
.....[1]

- (b) The same parallel beam of X-ray radiation is incident, separately, on samples of bone and of muscle.

Data for the thickness  $x$  of the samples of bone and of muscle, together with the linear attenuation (absorption) coefficients  $\mu$  of the radiation in bone and in muscle, are given in Fig. 10.1.

	$x/\text{cm}$	$\mu/\text{cm}^{-1}$
bone	1.5	2.9
muscle	4.0	0.95

Fig. 10.1

Determine the ratio

$$\frac{\text{intensity transmitted through bone}}{\text{intensity transmitted through muscle}}.$$

ratio = ..... [2]

[Total: 5]

- 11 A beam of light consists of a continuous range of wavelengths from 420 nm to 740 nm. The light passes through a cloud of cool gas, as shown in Fig. 11.1.

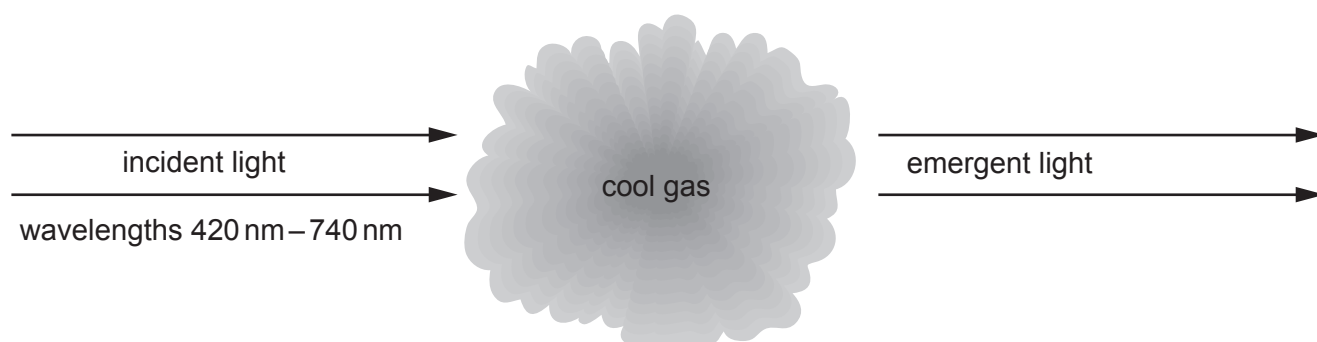


Fig. 11.1

- (a) The spectrum of the light emerging from the cloud of cool gas is viewed using a diffraction grating. Explain why this spectrum contains a number of dark lines.

.....

.....

.....

.....

.....

.....[4]

- (b) Some of the electron energy levels of the atoms in the cloud of gas are represented in Fig. 11.2.

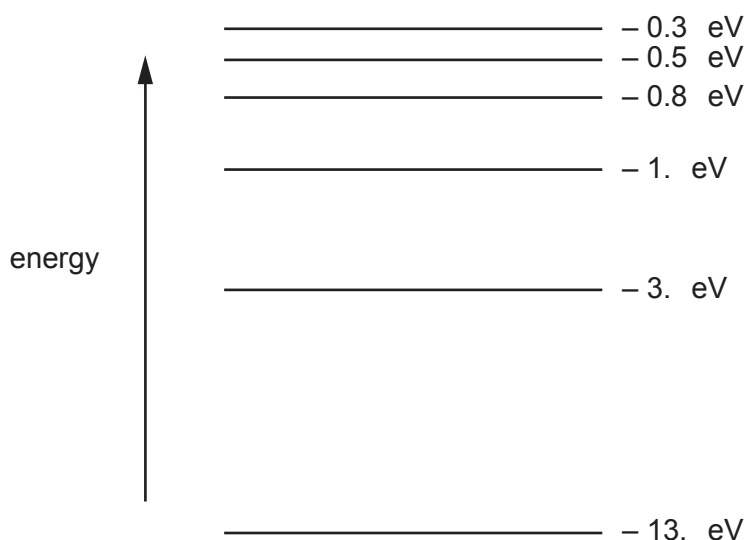


Fig. 11.2 (not to scale)

- (i) Light of wavelength 420 nm has a photon energy of 2.96 eV.

Calculate the photon energy, in eV, of light of wavelength 740 nm.

photon energy = ..... eV [2]

- (ii) Use data from (i) and your answer in (i) to show, on Fig. 11.2, the changes in energy levels giving rise to the dark lines in (a). [2]

[Total: 8]

- 10 (a) State what is meant by a *photon*.

.....  
.....[2]

- (b) Light in a beam has a continuous spectrum that lies within the visible region. The photons of light have energies ranging from 1.60 eV to 2.60 eV.

The beam passes through some hydrogen gas. It then passes through a diffraction grating and an absorption spectrum is observed.

- (i) All of the light absorbed by the hydrogen is re-emitted. Explain why dark lines are still observed in the absorption spectrum.

.....  
.....[1]

- (ii) Some of the energy levels of an electron in a hydrogen atom are illustrated in Fig. 10.1.

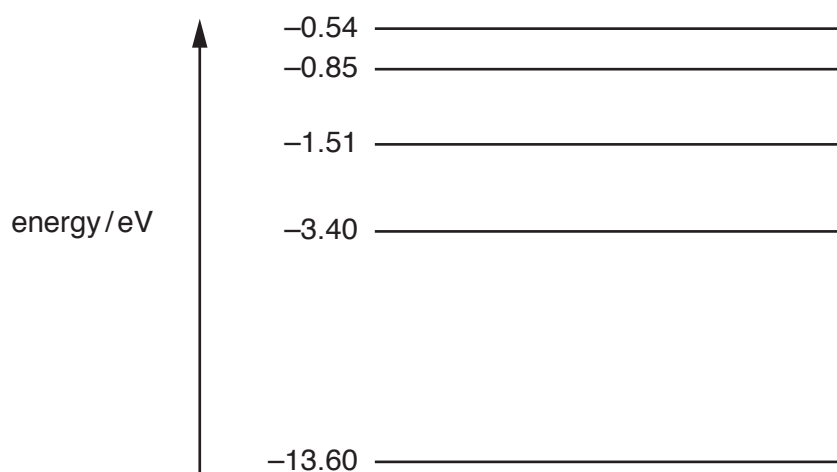


Fig. 10.1 (not to scale)

The dark lines in the absorption spectrum are the result of electron transitions between energy levels.

On Fig. 10.1, draw arrows to show the initial electron transitions between energy levels that could give rise to dark lines in the absorption spectrum. [2]

- (iii) Calculate the shortest wavelength of the light in the beam.

wavelength = .....m [3]

[Total: 8]

Question	Answer	Marks
10 (a) (i)	penetration of beam	1
	greater hardness means greater penetration/shorter wavelength/higher frequency/higher photon energy	1
	so provides the centripetal force	1
10 (a) (ii)	greater accelerating potential difference or greater p.d. between anode and cathode	1
10 (b)	$I = I_0 \exp(-\mu x)$ ratio = $(\exp \{-1.5 \times 2.9\}) / (\exp \{-4.0 \times 0.95\}) (= \exp \{-0.55\})$	1
	= 0.58	1
		Total: 6
11 (a)	electrons (in gas atoms/molecules) interact with photons	1
	photon energy causes electron to move to higher energy level/to be excited	1
	photon energy = difference in energy of (electron) energy levels	1
	when electrons de-excite, photons emitted in all directions (so dark line)	1
11 (b) (i)	photon energy $\propto 1 / \lambda$	1
	energy = 1.68 eV	1
	or	
	$E = hc / \lambda$ $E = 6.63 \times 10^{-34} \times 3.0 \times 10^8 / (740 \times 10^{-9})$ $= 2.688 \times 10^{-19} \text{ J}$	(1)
	energy = 1.68 eV	(1)
11 (b) (ii)	3.4 eV $\rightarrow$ 1.5 eV 3.4 eV $\rightarrow$ 0.85 eV 3.4 eV $\rightarrow$ 0.54 eV <i>all correct and none incorrect 2/2</i> <i>2 correct and 1 incorrect or only 2 correctly drawn 1/2</i>	2
		Total: 8

Question	Answer	Marks
10 (a)	packet / quantum of energy	1
	of electromagnetic radiation	1
10 (b) (i)	light is re-emitted in all directions / only part of the re-emitted light is in the direction of the beam	1
10 (b) (ii)	an arrow between $-3.40$ eV and $-1.51$ eV <u>and</u> an arrow between $-3.40$ eV and $-0.85$ eV	1
	all arrows shown point 'upwards'	1
10 (b) (iii)	$E = hc / \lambda$ or $E = hf$ and $c = f\lambda$	1
	$2.60 \times 1.60 \times 10^{-19} = (6.63 \times 10^{-34} \times 3.00 \times 10^8) / \lambda$	1
	$\lambda = 4.8 \times 10^{-7}\text{m}$	1
Total: 8		

Notes about the mark scheme are available separately.