2 - Particles and Waves Revision

1. Rutherford investigated the structure of the atom by carrying out his gold foil experiment.
State three conclusions from the Rutherford Scattering Experiment. **(3)**

2. The following expression represents a nuclear reaction:

$$^{1}_{0}n + ^{235}_{92}U \longrightarrow ^{137}_{56}Ba + ^{97}_{42}Mo + 2\,^{1}_{0}n + 6\,^{0}_{-1}e$$

The reaction involves the release of energy. The masses of the particles in the reaction are given below:

- Mass of $^{235}_{92}U$ = 390.2×10^{-27} kg
- Mass of $^{137}_{56}Ba$ = 227.3×10^{-27} kg
- Mass of $^{97}_{42}Mo$ = 160.9×10^{-27} kg
- Mass of $^{1}_{0}n$ = 1.675×10^{-27} kg

The mass of electrons is negligible.

a) (i) **Calculate the loss in mass** which occurs during the reaction. **(2)**
(ii) Find the **energy released** in the reaction. **(3)**

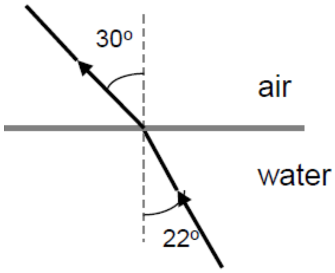
b) The reaction shown above is a nuclear fission reaction.
(i) **State the name** of another type of nuclear reaction. **(1)**
(ii) **Describe the difference** between these two types of reaction. **(2)**

3. An example of a nuclear decay equation is shown below:

$$^{218}_{84}Po \longrightarrow ^{214}_{82}Pb + X$$

a) **What kind** of nuclear radiation is emitted? **(1)**
b) What else could be emitted that is not given in the decay equation? **(1)**

4. a) The diagram below shows a ray of light of wavelength 600nm travelling from water to air.



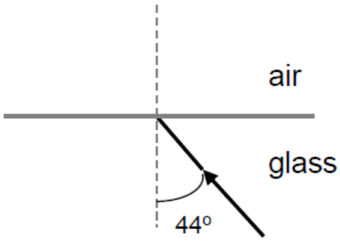
(i) Calculate the refractive index of the water. **(3)**

(ii) Calculate the speed of the light in water. **(3)**

(iii) Calculate the wavelength of the light in water. **(2)**

(iv) Calculate the critical angle of water. **(3)**

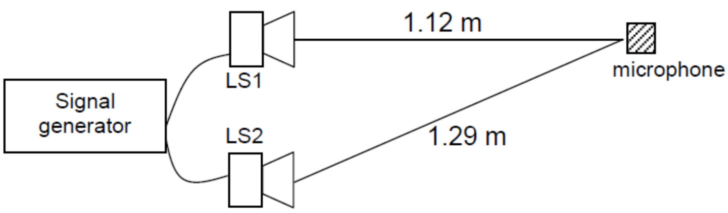
b) A ray of red light strikes a glass/air boundary as shown below.



The critical angle for red light in glass is 42°.

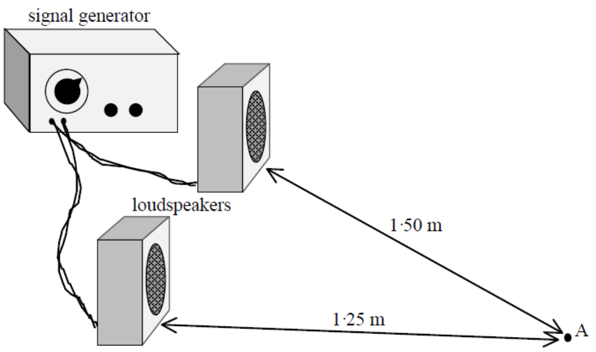
State and give a reason why this happens to the ray when it reaches the boundary. **A diagram may be included**. **(2)**

5. Loudspeakers 1 and 2 are both connected to the same signal generator which is set to produce a frequency of 4 kHz.
Loudspeaker 1 is switched on but loudspeaker 2 is switched off.



State and explain what happens to the **amplitude** of the signal picked up by the microphone when **loudspeaker 2 is switched on**.
Your explanation should include a calculation. **(3)**
(speed of sound in air = 340 ms^{-1})

6. Two loudspeakers are connected to a signal generator which produces a steady note of frequency of 3400Hz.



a) Calculate the wavelength of the sound waves produced by the loudspeakers. **(3)**

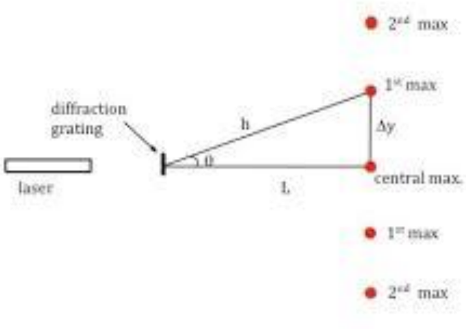
b) **Describe** what is meant by the terms constructive interference and destructive interference. **(2)**

c) A microphone is placed at position A which is 1.25m from one loudspeaker and 1.50m away from the other.

Provide evidence to state whether constructive or destructive Interference of the sound waves is taking place at point A. **(3)**

7. Light from a laser is directed at a grating and an interference pattern Is produced on a screen.

The laser light has a wavelength of 628 nm and the grating has 600 lines per millimetre.



a) Calculate is the **separation of the lines** on the grating **d**? **(1)**

b) Calculate the angle **ϴ.** **(3)**

c) **Which colour** of light is emitted by the laser? **(1)**

8. A photon of electromagnetic radiation, incident on the surface of a metal, may cause an electron to be ejected from the metal surface. The table below gives the minimum frequencies of radiation that can cause electrons to ne ejected from different metals.

Metal	Zinc	Sodium	Potassium	Gold
Threshold frequency, Hz	1.04×10^{15}	5.43×10^{15}	4.83×10^{14}	1.18×10^{15}

a) What is the **name given** to this effect? **(1)**

b) **Calculate the minimum energy** of a photon needed to eject an electron from a gold surface. **(3)**

c) (i) **Show which metal** from the table above, emits electrons when photons of **energy 3.50×10^{-19}J** are incident on it. **(3)**

(ii) What is the **maximum kinetic energy** gained by an ejected electron from this surface by a photon of energy 3.50×10^{-19}J. **(2)**

9. In an experiment dealing with photoelectric emission, a metal surface in an evacuated tube was illuminated with monochromatic light. If the experiment was repeated using light of **double the wavelength and double the irradiance**, **describe and explain** how this would affect **each case** below:

(a) the **energy of the photon** **(2)**

(b) the **maximum kinetic energy** gained by the photoelectrons **(2)**

(c) the **photoelectric current** produced? **(2)**

10. An astronomer measures the irradiance of light received from five identical stars on the Earth's surface.
Some of the data collected is shown in the table below:

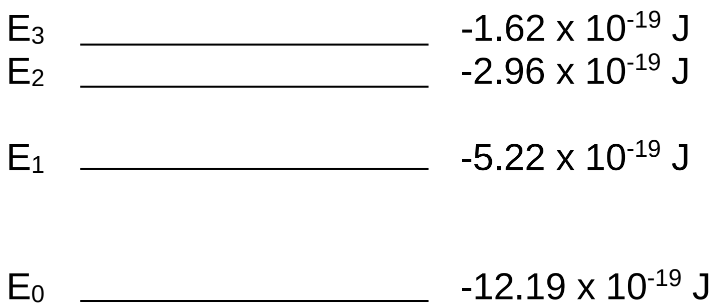
star	Distance from Earth, $\times 10^{18}$ m	Irradiance of light, $\times 10^{-2}$ Wm^{-2}
A	1.0	6.40
B	2.0	1.60
C	3.0	0.71
D	4.0	0.40
E	5.0	?

a) **Using the data from the first four stars,** find the relationship between the **Irradiance** of the light and the **distance** from the Earth. **(3)**

b) Find the **irradiance of star E** on the Earth's surface. **(3)**

11. a) **Draw a diagram** to represent four energy levels of an atom, labelling the ground state, ionisation level and an excited state. **(3)**

b) The diagram represents some energy levels in an atom of magnesium.



(i) **How many transitions** are possible in this energy level diagram? **(1)**

(ii) Explain which transition produces radiation with the longest wavelength. **(2)**

(iii) An electron moves from energy level E_2 to level E_0, producing a photon. Calculate the **wavelength** of the emitted photon. **(4)**

12. Different laser pointers emit visible light between 540nm (green) and 680nm (red), and have power outputs ranging from 0.6mW to 3.0mW.

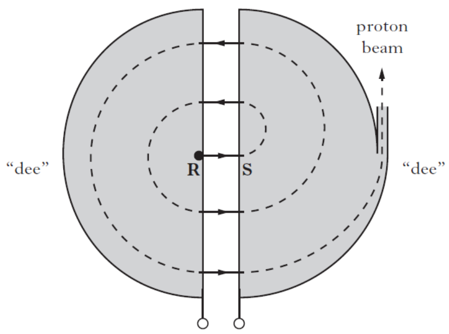
The cross-sectional area of the beam is typically 2 - 5mm^2 at the aperture, spreading out to 36 – 72mm^2 at a distance of 3 metres.

Calculate:

a)The **maximum irradiance** of the laser pointers at the aperture. **(3)**

b)The **range of irradiance** of the laser pointers at a distance of 3 metres. **(4)**

13. A cyclotron is made up of two D-shaped hollow structures which are placed in a vacuum and is used to accelerate protons.
A 40kV alternating current supply is used in the cyclotron below.



Protons are released from rest at R and accelerated across to gap to S by the 40kV supply.

a) Calculate the **work done** on a proton as it accelerates from R to S. **(3)**

b) Calculate the **speed** of the proton as it reaches S. **(3)**

c) Inside the 'dees' a uniform magnetic field acts on the protons.

Determine the direction of this magnetic field using Flemings right hand rule. **(1)**

d) Explain why a cyclotron uses an ac supply. **(2)**

14. a) **Name the force** which holds particles together in the nucleus of an atom. **(1)**

b) Some unstable nuclei break down (decay) by emitting beta particles.
Name the force associated with beta decay. **(1)**

15. a) i) How many quarks combine to form a baryon? **(1)**

ii) Are baryons short or long lived particles? **(1)**

iii) Which combination of quarks make up a baryon? **(1)**

b) i) How many quarks combine to form a meson? **(1)**

ii) Are mesons short or long lived particles? **(1)**

iii) Which combination of quarks make up a meson? **(1)**

c) Using the table below which combination of quarks form:

i) A proton **(1)**

ii) An antiproton **(1)**

iii) A pi-meson **(1)**

Properties of elementary particles			
Particle	Number of quarks	Charge	Baryon number
Proton	3	+e	1
Antiproton	3	−e	−1
Pi-meson	2	−e	0

Properties of quarks and antiquarks		
Particle	Charge	Baryon number
Up quark	$+\frac{2}{3}e$	$+\frac{1}{3}$
Down quark	$-\frac{1}{3}e$	$+\frac{1}{3}$
Anti-up quark	$-\frac{2}{3}e$	$-\frac{1}{3}$
Anti-down quark	$+\frac{1}{3}e$	$-\frac{1}{3}$

Total Marks = 100