Grade 12 May 2020
Doppler and photoelectric effect - online test

Instructions:

- Round off all values to 2 decimal places
- Don't leave spaces in your answers between numbers and units
- Use decimal **,** NOT **.**

DATA FOR PHYSICAL SCIENCES GRADE 12

NAME	SYMBOL	VALUE
Speed of light in a vacuum	c	$3{,}0 \times 10^{8}$ m·s^{-1}
Planck's constant	h	$6{,}63 \times 10^{-34}$ J·s
Charge on electron	e	$-1{,}6 \times 10^{-19}$ C
Electron mass	m_e	$9{,}11 \times 10^{-31}$ kg

WAVES, SOUND AND LIGHT

$v = f\lambda$	$T = \frac{1}{f}$
$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ or/*of* $f_L = \frac{v \pm v_L}{v \pm v_b} f_b$	$E = hf$ $E = h\frac{c}{\lambda}$
	$E = W_o + E_k$ where/*waar* $E = hf$ and/*en* $W_0 = hf_0$ and/*en* $E_k = \frac{1}{2}mv^2$

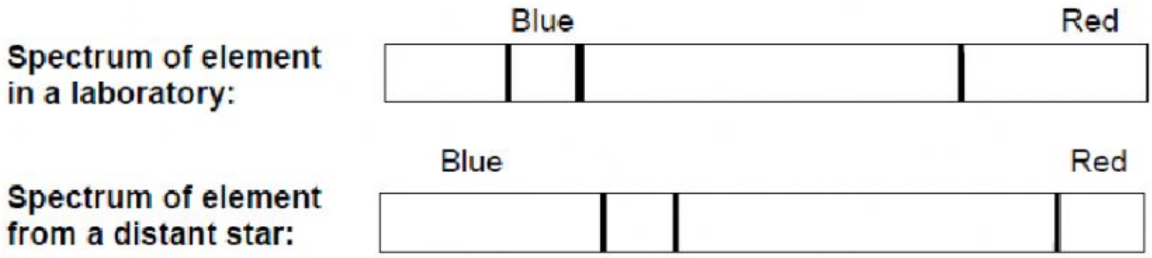
Question 1

Multiple choice questions: Only write the letter of the correct option

1.1 A line emission spectrum is produced when an electron in an excited atom makes a transition from …

A higher to lower energy levels and emit light energy.
B higher to lower energy levels and absorb light energy.
C lower to higher energy levels and emit light energy.
D lower to higher energy levels and absorb light energy.

1.2 Astronomers obtained the following spectral lines of an element:



The observation confirms that the ...

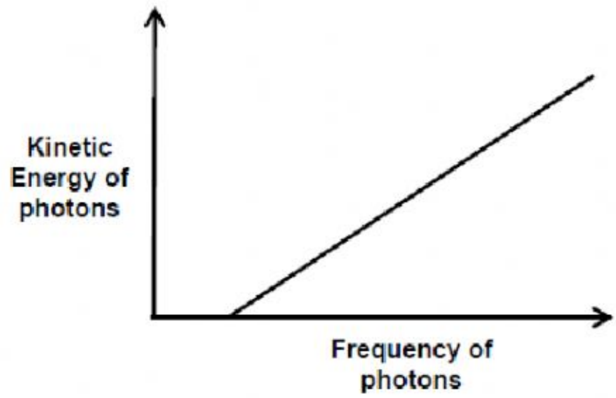
A star is moving closer towards earth.

B earth is moving towards the star.

C temperature of earth is increasing.

D universe is expanding.

1.3 A graph of the kinetic energy of photons of light versus the frequency of the photons is shown below.



What is represented by the gradient of the above graph?

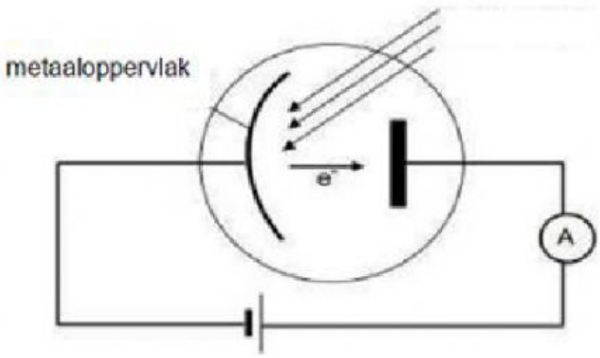
A Plank's Constant

B threshold frequency

C speed of light

D mass of the photon

1.4 A metallic surface is first irradiated with **ultraviolet light** and THEN with **infrared light** of the SAME intensity as shown in the circuit below. Both forms of light emit electrons from the metal surface.



How will the kinetic energy of the emitted photoelectrons and reading on the ammeter change when the two different forms of lights are used?

	Kinetic Energy of photoelectrons	Reading on the ammeter
A	decrease	decrease
B	increase	same
C	decrease	same
D	same	increase

1.5 A neon tube lights up when a large external voltage is applied across it. Which ONE of the following best describes the type of spectrum observed when the gas inside the tube is observed through a diffraction grating?

A Absorption spectrum

B Continuous emission spectrum

C Line absorption spectrum

D Line emission spectrum

1.6 How do the emission and absorption spectra of an element differ?

A The emission spectrum contains more lines than the absorption spectrum.
B The emission spectrum is shifted to the left (toward the blue side) of the absorption spectrum.
C The emission spectrum is shifted to the right (toward the red side) of the absorption spectrum.
D The lines are in the same wavelength positions, but are bright and coloured for the emission spectrum and black for the absorption spectrum.

1.7 A stationary ambulance has its siren on. A girl moves away from the ambulance with a constant velocity $\mathbf{v_x}$. The ratio of the actual frequency of the siren of the ambulance to the apparent frequency as heard by the girl is 1,25.

The girl now stands still and the ambulance moves away from her with the same velocity $\mathbf{v_x}$. What will be the ratio of the actual frequency of the siren to the apparent frequency as heard by the girl?

A 1,2

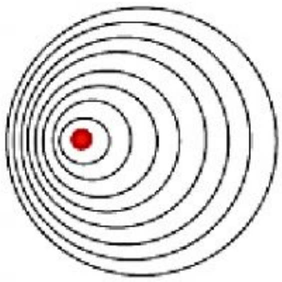
B 1,25

C 1,4

D 1,5

Question 2

The following diagram shows a moving source of sound waves



2.1 What is the phenomenon illustrated above called? [TWO WORDS]

2.2 In which direction is the source moving? LEFT / RIGHT

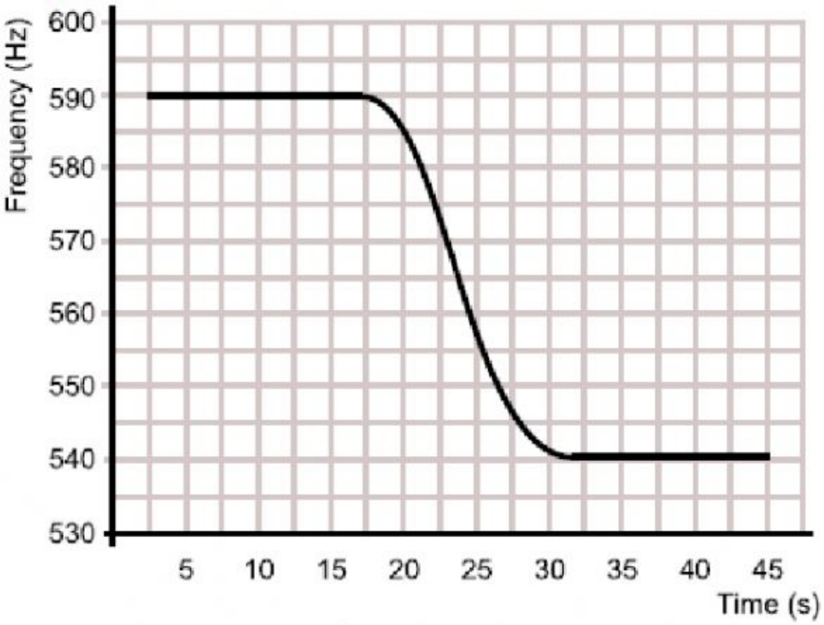
2.3 What happens to the observed wavelength of the waves at the left side of the source?

INCREASES / DECREASES / REMAINS THE SAME

2.4 You are a stationary observer and the sound source moves away from you. How will the pitch of the sound you hear differ from the pitch when the sources is stationary?

HIGHER / LOWER / THE SAME

A train passes a learner at a constant speed while sounding its whistle. The following graph shows how the frequency of the whistle changes as the train approaches and passes the stationary learner



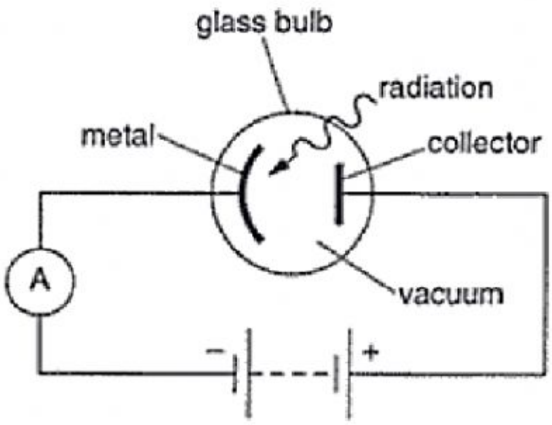
2.5 If the train is travelling at 15,04m.s^{-1}, and sound travels at 340m.s^{-1} in air, calculate the frequency of the sound being emitted by the train.

$$f_L = \frac{v \pm v_L}{v \pm v_s} . f_s$$

f_s =

Question 3

The diagram represents a photocell. When the metal surface is exposed to electromagnetic radiation, photoelectrons are ejected. The collector collects the photoelectrons and the sensitive ammeter indicates the presence of a tiny current. The metal has a work function of 3,5 x 10^{-19} J.



3.1 Name the frequency that is associated with work function.

3.2 Calculate the maximum kinetic energy of an ejected photoelectron when the incident radiation is 429 nm.

$$E = \frac{h\,c}{\lambda} \qquad E = W_0 + E_{k(max)}$$

$$\frac{h\,c}{\lambda} = W_0 + E_{k(max)}$$

$$\frac{(\qquad \times 10\quad) \times (\qquad \times 10\quad)}{\times 10} = (\qquad\qquad \times 10\quad) + E_{k(max)}$$

$$E_{k(max)} = \qquad \times 10$$

UNITS

3.3 The intensity of the incident radiation is doubled but the wavelength is kept constant. State the effect that this has on each of the following:

3.3.1 the energy of each photon
INCREASE / DECREASE / REMAIN THE SAME

3.3.2 the maximum kinetic energy of each photoelectron
INCREASE / DECREASE / REMAIN THE SAME

3.3.3 the current in the photocell
INCREASE / DECREASE / REMAIN THE SAME

Question 4

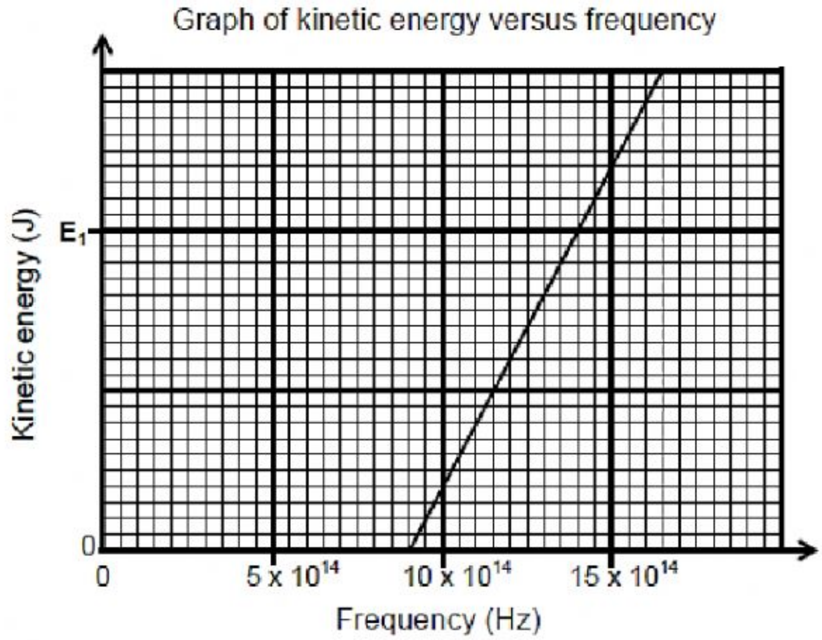
During an investigation, light of different frequencies is shone onto the metal cathode of a photocell. The kinetic energy of the emitted photoelectrons is measured. The graph below shows the results obtained.

4.1 For this investigation, write down the following:

4.1.1 Dependent variable

4.1.2 Independent variable

4.1.3 Controlled variable



4.2 Use the graph to obtain the threshold frequency of the metal used as a cathode in the photocell.

Threshold frequency = x 10

4.3 Calculate the value of the kinetic energy at E_1 shown on the graph.

$$E = W_0 + E_k$$

$$hf = hf_0 + E_k$$

(x10)(x10) = (x10)(x10) + E_k

E_k = x 10

4.4 How would the kinetic energy calculated in QUESTION 4.3 be affected if light of higher intensity is used?

INCREASE / DECREASE / REMAIN THE SAME

Question 5

A learner conducts an experiment to determine which metal(s) will release electrons when green light of WAVELENGTH 510 nm is shone on it. The table below shows the different metals used in the experiment with their respective work functions.

Metal	Work Function (J)
Gold	$8,16 \times 10^{-19}$
Aluminium	$6,88 \times 10^{-19}$
Sodium	$4,32 \times 10^{-19}$
Caesium	$3,36 \times 10^{-19}$

5.1 Calculate the energy of a photon of green light.

$$E = \frac{hc}{\lambda} = \frac{(\quad \times 10 \quad)(\quad \times 10 \quad)}{\times 10}$$

$$E = \quad \times 10$$

5.2 Using the data from the above table, identify the metal/s which will release photoelectrons when green light is shone onto their surfaces.

Gold
Aluminium
Sodium
Caesium

5.3 Calculate the maximum kinetic energy of a photoelectron when green light shines onto the metal in QUESTION 5.2.

$$E = W_0 + E_k$$

$E_k = \quad - \quad$ (rearrange the above formula – <u>symbols</u> not numbers)

$= (\quad \times 10 \quad) - (\quad \times 10 \quad)$

$= \quad \times 10$

5.4 The intensity of the green light is DOUBLED. State the effect that this has on each of the following:

5.4.1 The work function of each metal

INCREASE / DECREASE / REMAIN THE SAME

5.4.2 The maximum kinetic energy of each emitted photoelectron

INCREASE / DECREASE / REMAIN THE SAME

5.4.1 The energy of each photon of green light

INCREASE / DECREASE / REMAIN THE SAME

Question 6 - Extension Question for Miss Badenhorst's class:

Humpback whales and bottlenose dolphins emit sound waves that range from 0,2 to 150 kHz as they travel through water. A scientist immerses a frequency meter under water to determine the frequency of the sound that a dolphin emits. The scientist finds that the frequency meter registers a frequency of 50 kHz as the dolphin approaches him at a constant speed and 49 kHz as it moves away from him at the same speed.

6.1 If the speed of sound in water is 1560 $m.s^{-1}$, calculate the actual frequency of the sound made by the dolphin.

Which version/s of the Doppler formula apply to this problem?

$f_L = \frac{v + v_L}{v \pm 0} . f_s$ $f_L = \frac{v - v_L}{v \pm 0} . f_s$ $f_L = \frac{v \pm 0}{v + v_s} . f_s$ $f_L = \frac{v \pm 0}{v - v_s} . f_s$

Use simultaneous equations to calculate the final answer:

f_s =

6.2 Hence determine the speed at which the dolphin is moving.

v_s =