FUKIEN SECONDARY SCHOOL

S6 First Term Uniform Test (2020–2021)

Physics

(1 hour)

Date: 20th October 2020 Name: ______________________

Time: 10:30a.m. – 11:30a.m. Class: __________ No.:________

Instructions to students:

1. Write your name, class and class number on both the question paper and the answer sheets.
2. Answer ALL questions.
3. Write down all the answers on the answer sheets.
4. Hand in the question paper and the answer sheets at the end of the examination.
5. The total mark of the paper is 40.
6. The paper consists of two sections: Section A Multiple Choice Questions (20 marks) and Section B Structured Questions (20 marks).
7. The numerical answers should be either exact or correct to 3 significant figures.
8. The last two pages of this paper contain a list of data, formulae and relationships which you may find useful.

Section A: Multiple Choice Questions (20 marks)

1. A student studies the radiation emitted by a radioactive source. A GM tube is placed in front of the source. Different absorbers are placed in turn between the source and the GM tube and four readings are taken for each absorber. The following table shows the results of the experiment.

Absorber	Recorded count rate / counts per minute			
Air	1020	1113	1064	1110
A piece of paper	760	734	742	731
5 mm aluminium	749	753	727	710
25 mm lead	380	376	384	367

What type(types) of radiation does(do) the source emit?

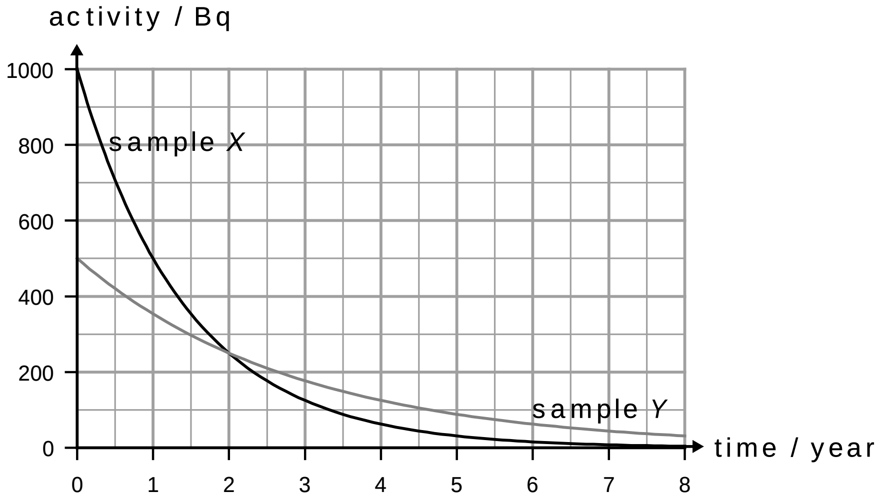
A. α

B. β

C. α and γ

D. β and γ

2. The graph below shows the activities of two radioactive samples *X* and *Y* in 8 years.



Which of the following statements is/are correct?

(1) Sample *X* has a longer half-life than sample *Y*.

(2) Sample *X* has a half-life of one year.

(3) The rate of radioactive decay taking place in sample *X* is always higher than that in sample *Y*.

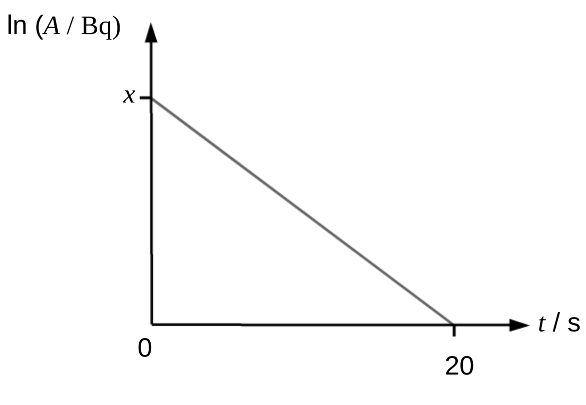
A. (1) only

B. (2) only

C. (1) and (3) only

D. (2) and (3) only

3. The graph below shows how the natural logarithm of the activity *A* of a radioactive sample varies with time *t*. The half-life of the sample is 6.93 s.



What is the value of *x*?

A. 0.2

B. 1.4

C. 2

D. 14

4. Which of the following statements about nuclear fission is/are correct?

(1) The rate of fission always decreases exponentially with time.

(2) In nuclear fission, a heavy nucleus is split into two or more lighter nuclei.

(3) Chain reactions occur whenever there are fission reactions.

A. (2) only

B. (3) only

C. (1) and (2) only

D. (1) and (3) only

5. A nuclear reactor generates 1000 MW of electrical power at an efficiency of 20%. Calculate the rate at which the nuclear fuel in the reactor loses its mass.

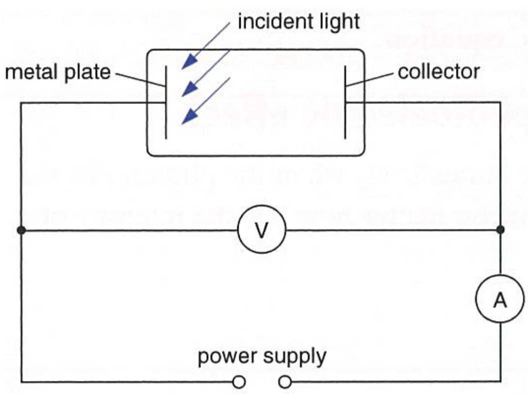
A. 1.11×10^{-11} kg s^{-1}

B. 5.56×10^{-11} kg s^{-1}

C. 1.11×10^{-8} kg s^{-1}

D. 5.56×10^{-8} kg s^{-1}

6. A photocell is connected as shown below. Monochromatic light is directed to the metal plate and a photoelectric current is produced. The stopping potential is the potential difference across the metal plate and the collector just enough to cease the current.



Which of the following changes to the set-up would give a smaller stopping potential?

(1) Light of a longer wavelength is directed to the metal plate.

(2) Light of a smaller intensity is directed to the metal plate.

(3) A metal plate of larger work function is used in the photocell.

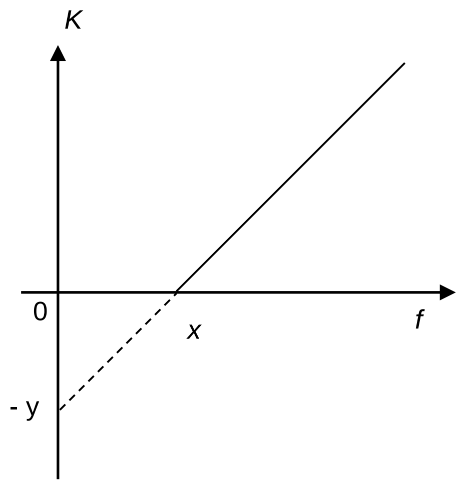
A. (1) only

B. (3) only

C. (1) and (2) only

D. (1) and (3) only

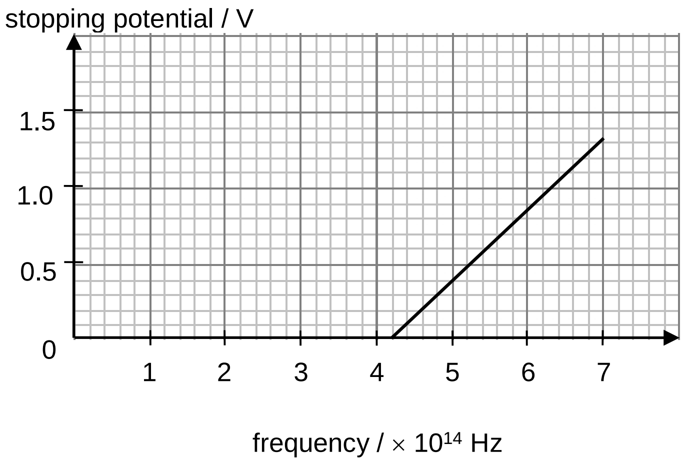
7. In an experiment studying photoelectric effect, a metal surface is illuminated by electromagnetic radiation of different frequencies. A graph showing the relationship between the maximum kinetic energy K of the photoelectrons emitted and the frequency f of the incident light is then obtained.



Which of the following gives the work function of the metal?

A. $-y$
B. $h\,y$
C. $-x$
D. $e\,x$

8. In the experiment studying photoelectric effect, a graph showing the relationship between the stopping potential and the frequency of the incident light is obtained.



Estimate Planck constant from the above graph.

A. 5.3×10^{-34} J s
B. 6.0×10^{-34} J s
C. 6.7×10^{-34} J s
D. 7.4×10^{-34} J s

9. Which of the following statements about an induction cooker is/are correct?
   (1) Its top plate is usually made of metal.
   (2) It emits electromagnetic waves which are absorbed by the food.
   (3) It has a high end-use energy efficiency.
   A. (1) only
   B. (3) only
   C. (1) and (2) only
   D. (2) and (3) only

10. Which of the following about LED lights are correct?
   (1) The brightness control of LED bulbs is difficult.
   (2) An LED bulb emits light mainly by combining electrons in the p-type semiconductor and holes in the n-type semiconductor.
   (3) The colour of an LED light depends only on the materials forming the PN junction.
   A. (1) and (2) only
   B. (1) and (3) only
   C. (2) and (3) only
   D. (1), (2) and (3)

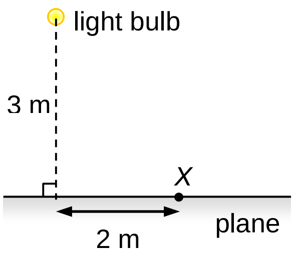
11. Which of the following factors affect(s) the thermal transmittance (U-value) of a wall?
   (1) Thickness of the wall
   (2) Area of the wall
   (3) Temperature difference between the two sides of the wall
   A. (1) only
   B. (1) and (2) only
   C. (2) and (3) only
   D. (1), (2) and (3)

12. In a hydroelectric power station, the water level of the upper reservoir is 120 m above that of the lower reservoir. If the power output of the station is 2 GW and its efficiency is 75%, how much water flows through the dam each minute? (Given: 1 GW = 10^9 W)
   A. 2.27×10^6 kg
   B. 7.65×10^7 kg
   C. 1.02×10^8 kg
   D. 1.36×10^8 kg

13. A 1500-W air conditioner can remove 180 000 J of heat from a room in one minute. What is the coefficient of performance (COP) of the air conditioner?

A. 2
B. 3
C. 120
D. 3000

14. A plane is illuminated by a light bulb which has a luminous flux of 1600 lm. Assume that the light bulb is a point source. What is the illuminance at point *X* on the plane?



A. 8.14 lx
B. 29.4 lx
C. 35.3 lx
D. 1600 lx

15. Uranium-235 can undergo the following nuclear fission reaction.

$$^{235}_{92}\mathrm{U} + ^{1}_{0}\mathrm{n} \rightarrow ^{90}_{37}\mathrm{Rb} + ^{144}_{55}\mathrm{Cs} + 2^{1}_{0}\mathrm{n}$$

Given:

mass of one $^{235}_{92}\mathrm{U}$ nucleus = 235.0439 u

mass of one $^{90}_{37}\mathrm{Rb}$ nucleus = 89.914 80 u

mass of one $^{144}_{55}\mathrm{Cs}$ nucleus = 143.9321 u

mass of one neutron = 1.008 665 u

What is the energy released during the reaction?

A. 9.38×10^{-11} J
B. 2.81×10^{-11} J
C. 1.88×10^{-11} J
D. 1.69×10^{-11} J

16. Which of the following is/are the advantage(s) of fossil-fuel vehicles over hybrid vehicles?
    (1) The braking system is more efficient.
    (2) The re-fueling time is shorter.
    (3) The selling price is lower.
    A. (1) only
    B. (2) only
    C. (3) only
    D. (1) and (3) only

End of Section A

Section B: Structured Questions (20 marks)

1. A mixed source of α radiation and β radiation is next to a uniform magnetic field. Radiation is directed into the field as shown in Figure 1.

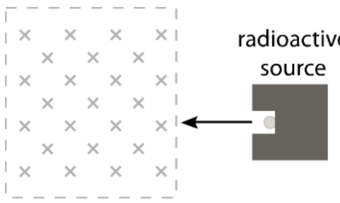


Figure 1

(a) Sketch the path of the radiation inside the magnetic field. (2 marks)

(b) The experiment is carried out in a vacuum chamber rather than in air if we wish to determine the exit positions of the radiation. Why? (1 mark)

(c) The activity of the source drops to 1/10 of the original after 10 years. What is the half-life of the source? (2 marks)

2. Figure 2 shows the circuit set up of the experiment to investigate the photoelectric effect.

Given: The wavelength of green light = 495 nm

The threshold frequencey of the metal = 5.10×10^{14} Hz

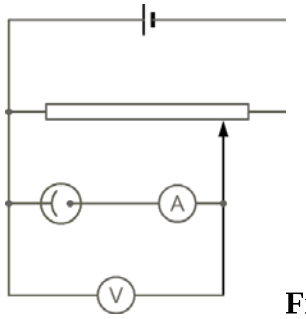


Figure 2

(a) (i) Find the work function of the metal in electron-volts. (1 mark)

(ii) Calculate the maximum kinetic energy of the emitted photoelectrons in electron-volts. Hence find the stopping potential. (2 marks)

(b) Describe any change to the stopping potential if the metal plate is illuminated by

(i) blue light of the same intensity, and (1 mark)

(ii) green light of the same wavelength but of higher intensity respectively. (1 mark)

(c) Give ONE evidence to suport that the result of the photoelectric effect experiment favours the particle theory of light instead of the wave theory. (1 mark)

3. Nowadays, buses are equipped with air-conditioning systems to maintain a comfortable temperature inside the bus compartments. Figure 3 shows the simplified structure of the air-conditioning system in a double decker bus.

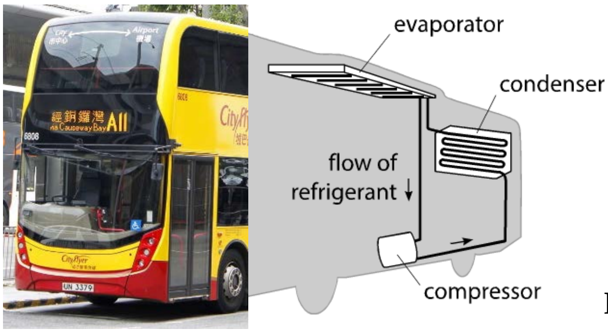


Figure 3

(a) Explain the following designs of the air-conditioning system in the bus.

(i) The evaporator is installed at the rooftop of the bus compartment. (1 mark)

(ii) The tubes in the evaporator and the condenser are coiled. (1 mark)

(b) The air-conditioning system in the bus operates for 18 hours a day. It has a cooling capacity of 55 kW and a coefficient of performance (COP) of 3.6. The latent heat of vaporization of the refrigerant flowing in the system is 167 000 J kg^{-1}.

(i) How much work is required for the air-conditioning system to remove heat from the bus compartment in one day? (2 marks)

(ii) Estimate the average flow rate (in kg s^{-1}) of the refrigerant when the air-conditioning system operates. Assume that the heat loss to the surroundings is negligible. (2 marks)

(c) When the bus is parked at the terminus, its air-conditioning system is switched off. If the terminus is an open area, heat from sunlight is continuously transferred to the bus compartment during daytime. The bus compartment becomes very hot. Thus air-conditioning system consumes more energy to cool down the bus compartment to a comfortable temperature during the next journey.

(i) Some heat gain of the bus compartment is by conduction through the bus body. To reduce such heat gain, explain which material, fibreglass or steel, should be more likely to make the bus body.

Given: thermal transmittance of fibreglass is 1.08 W m^{-2} K^{-1},

thermal transmittance of steel is 1170 W m^{-2} K^{-1}. (2 marks)

(ii) Some heat gain of the bus compartment is by radiation through the windows. Suggest **ONE** modification on the **DESIGN OF WINDOWS** to reduce such heat gain. (1 mark)

End of Section B

END OF PAPER

List of data, formulae and relationships

Data

molar gas constant	$R = 8.31\ \text{J mol}^{-1}\ \text{K}^{-1}$
Avogadro constant	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$
acceleration due to gravity	$g = 9.81\ \text{m s}^{-2}$ (close to the Earth)
universal gravitational constant	$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$
speed of light in vacuum	$c = 3.00 \times 10^8\ \text{m s}^{-1}$
charge of electron	$e = 1.60 \times 10^{-19}\ \text{C}$
electron rest mass	$m_e = 9.11 \times 10^{-31}\ \text{kg}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2\ \text{N}^{-1}\ \text{m}^{-2}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ \text{H m}^{-1}$
atomic mass unit	$\text{u} = 1.661 \times 10^{-27}\ \text{kg}$ (1 u is equivalent to 931 MeV)
astronomical unit	$\text{AU} = 1.50 \times 10^{11}\ \text{m}$
light year	$\text{ly} = 9.46 \times 10^{15}\ \text{m}$
parsec	$\text{pc} = 3.09 \times 10^{16}\ \text{m} = 3.26\ \text{ly} = 206\ 265\ \text{AU}$
Stefan constant	$\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$

Rectilinear motion

For uniformly accelerated motion:

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

Mathematics

Equation of a straight line	$y = mx + c$
Arc length	$= r\theta$
Surface area of cylinder	$= 2\pi rh + 2\pi r^2$
Volume of cylinder	$= \pi r^2 h$
Surface area of sphere	$= 4\pi r^2$
Volume of sphere	$= \frac{4}{3}\pi r^3$

For small angles, $\sin\theta \approx \tan\theta \approx \theta$ (in radians)

Atomic World

$$\frac{1}{2}m_e {v_{max}}^2 = hf - \phi$$

Einstein's photoelectric equation

$$E_n = -\frac{1}{n^2}\left\{\frac{m_e e^4}{8h^2\epsilon_0^2}\right\} = -\frac{13.6}{n^2}\text{eV}$$

Energy level equation for hydrogen atom

$\lambda = \frac{h}{p} = \frac{h}{mv}$ de Broglie formula

$\theta \approx \frac{1.22\lambda}{d}$ Rayleigh criterion (resolving power)

Energy and Use of Energy

$E = \frac{\Phi}{A}$ illuminance

$\frac{Q}{t} = k\frac{A(T_H - T_C)}{d}$ rate of energy transfer by conduction

$U = \frac{k}{d}$ thermal transmittance U-value

$P = \frac{1}{2}\rho A v^3$ maximum power by wind turbine

A1.	$E = mc\Delta T$	energy transfer during heating and cooling
A2.	$E = l\Delta m$	energy transfer during change of state
A3.	$pV = nRT$	equation of state for an ideal gas
A4.	$pV = \frac{1}{3}Nm\overline{c^2}$	kinetic theory equation
A5.	$E_K = \frac{3RT}{2N_A}$	molecular kinetic energy
B1.	$F = m\frac{\Delta v}{\Delta t} = \frac{\Delta p}{\Delta t}$	force
B2.	moment = $F \times d$	moment of a force
B3.	$E_P = mgh$	gravitational potential energy
B4.	$E_K = \frac{1}{2}mv^2$	kinetic energy
B5.	$P = Fv$	mechanical power
B6.	$a = \frac{v^2}{r} = \omega^2 r$	centripetal acceleration
B7.	$F = \frac{Gm_1m_2}{r^2}$	Newton's law of gravitation
C1.	$\Delta y = \frac{\lambda D}{a}$	fringe width in double-slit interference
C2.	$d \sin\theta = n\lambda$	diffraction grating equation
C3.	$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$	equation for a single lens
D1.	$F = \frac{Q_1Q_2}{4\pi\varepsilon_0 r^2}$	Coulomb's law
D2.	$E = \frac{Q}{4\pi\varepsilon_0 r^2}$	electric field strength due to a point charge
D3.	$E = \frac{V}{d}$	electric field between parallel plates (numerically)
D4.	$R = \frac{\rho l}{A}$	resistance and resistivity
D5.	$R = R_1 + R_2$	resistors in series
D6.	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$	resistors in parallel
D7.	$P = IV = I^2R$	power in a circuit
D8.	$F = BQv \sin\theta$	force on a moving charge in a magnetic field
D9.	$F = BIl \sin\theta$	force on a current-carrying conductor in a magnetic field
D10.	$B = \frac{\mu_0 I}{2\pi r}$	magnetic field due to a long straight wire
D11.	$B = \frac{\mu_0 NI}{l}$	magnetic field inside a long solenoid
D12.	$\varepsilon = N\frac{\Delta\Phi}{\Delta t}$	induced e.m.f.
D13.	$\frac{V_s}{V_p} \approx \frac{N_s}{N_p}$	ratio of secondary voltage to primary voltage in a transformer
E1.	$N = N_0 e^{-kt}$	law of radioactive decay
E2.	$t_{\frac{1}{2}} = \frac{\ln 2}{k}$	half-life and decay constant
E3.	$A = kN$	activity and the number of undecayed nuclei
E4.	$\Delta E = \Delta mc^2$	mass-energy relationship

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S6 First Term Uniform Test (2020–2021)

Physics

Answer Sheet

(1 hour)

Date: 20th October 2020 Name: ______________________

Time: 10:30a.m. – 11:30a.m. Class: __________ No.:________

Section A: Multiple Choice Questions (20 marks)

1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**
11.	**12.**	**13.**	**14.**	**15.**	**16.**				

Section B: Structured Questions (20 marks)

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END OF ANSWER SHEET