RWANDA-MINEDUC

TTCs JOINT EXAMINATIONS

TTC COMPREHENSIVE EXAM | MAXIMUM MARKS: 100

LEVEL: YEAR II | Date: 10/03/2023

OPTION: SME | Duration: 3hours

TERM: II

SUBJECT: PHYSICS

INSTRUCTIONS:

1) Organize your time so that you can complete all questions.
2) Do not answer unnecessary things, answer what is asked.
3) Do not open this question paper until you are told to do so.
4) Draw a line after each question
5) This paper consists of three sections **A**, **B and C.**
   Section A: Attempt **ALL** questions. **(55 marks)**
   Section B: Attempt **any three** questions. **(30 marks)**
   Section C: Compulsory questions. **(15 marks)**
6) Non-programmable scientific calculator and mathematical set may be used.
7) Useful constants

$The\ mass\ of\ electron\ \ m_{e=}9.11x\ 10^{-31}kg$

$Planck's constant\ h\ =\ 6.62x10^{-34}J.s$

$Speed\ of\ light\ in\ vacuum\ C\ =\ 3x10^{8}m/_{s}$

$Electron\ charge\ e\ =\ 1.6x10^{-19}c$

$$Acceleration\ due\ to\ gravity\ g\ =\ 9.81\frac{m}{s^2}$$

SECTION A: Attempt all questions **(55marks)**

1) Isochoric process, isobaric process, isothermal process and adiabatic process can be done on ideal gas.

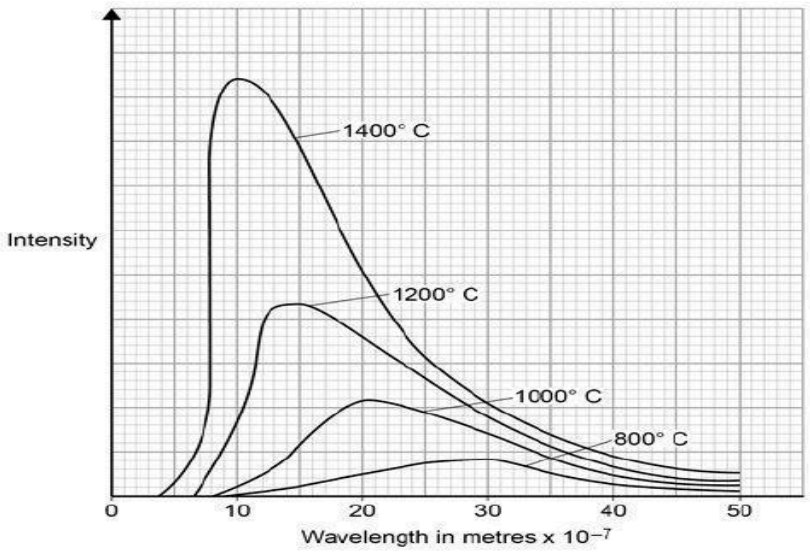
(a) Explain any one process from the list, using simple words **(1 mark)**

(b) For which process does the work done $W = 0$ **(1 mark)**

(c) Identify the process for which the variation of internal energy of a system

$$\Delta E_{int} = W$$ **(1 mark)**

2) Analyse the following graph of intensity of black body radiation against its wavelength for different temperatures **(** $figure$ 1**)**



$Figure$ 1

Answer questions related to the graph

a) What happens to the intensity of black body radiation when its wavelength decreases? Explain your answer. **(2 marks)**
b) According to the theory of black body radiation, do you emit blackbody radiation? Explain your answer. **(2 marks)**

3) The radius of a geostationary orbit from the Centre of the earth (orbit completed by a communication satellite in 24 hours) is 42 200 km.

a) Use this information with Kepler's third law (law of periods) of planetary motion to estimate the radius of a circular orbit completed by a satellite around the earth in 90 minutes. **(3 marks)**

b) What is the height of this satellite above the earth's surface? **(1 mark)**

4) In a certain process, 5000J of heat is added to a system heat while the system does a work equivalent t0 7000J work W by expanding against the surrounding atmosphere.

a) Use thermodynamics sign conventions to answer the question below:

Are the heat Q added to a system (absorbed by the system) and the work W done by the system positive or negative? **(2 marks)**

b) What is the change in internal energy for the system? **(2 marks)**

5) Copy and complete the sentences below using the following terms **electromagnetic radiation, phenomenon, electrons, light.** **(2 marks)**

Photoelectric effect is a ..... in which electrically charged particles are released from or within a material when it absorbs..... .

The effect is often defined as the ejection of ..... from a metal plate when ..... falls on it.

6) Analyse the following figure related to Carnot engine **(** *figure* 2**)**.

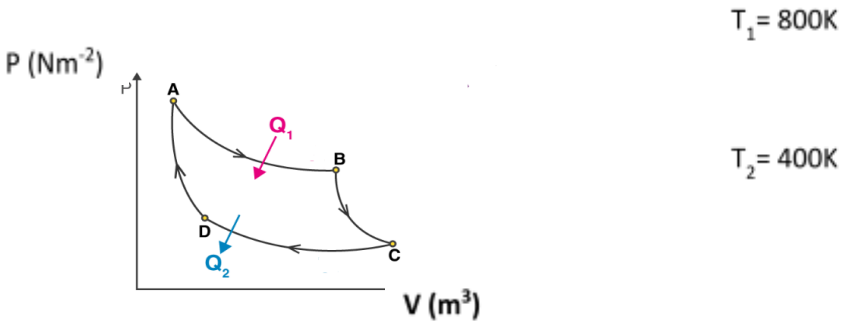


Figure 2

a) Find the efficiency of this Carnot engine. **(2 marks)**
b) If heat absorbed by the engine Q_1=10 000J, what is work done by the Carnot engine? **(2 marks)**
c) Find the heat output Q_2 **(1 mark)**

7) Russia state-owned nuclear company Rosa tom Global reached an agreement to set up in Rwanda the nuclear power plant by 2024.After signing this agreement on the use of nuclear energy, the Rwandan cabinet approved the establishment of the Rwandan Atomic Energy Board, an institution to coordinate nuclear science and technology activities in the country.

Formulate any **three** recommendations to Rwanda Atomic Energy Board on the safety measures associated with the production and use of nuclear energy that will be taken. **(3 marks)**

8) The planet is revolving around the Sun as shown in elliptical path (figure 3).

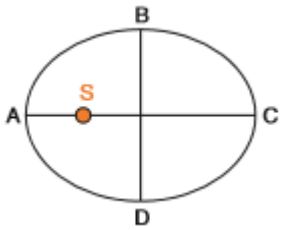


Figure 3

Considering figure 3, state whether each of the following statements is **true** or **false**

a) The time taken in travelling DAB is less than that for BCD **(1 mark)**
b) The time taken in travelling CDA is greater than that of ABC **(1 mark)**
c) Kinetic energy is maximum at A **(1 mark)**
d) Potential energy at A is greater than that at C **(1 mark)**
e) Potential energy is maximum at C **(1 mark)**

9) Light of wavelength 650 nm is incident normally on a double slit arrangement. The interference fringes formed are viewed on a screen parallel to and 1.2 m from the plane of the double slit.

The fringe separation /width is 0.750 mm.

a) Calculate the separation of the slits. **(2 marks)**
b) The separation between the two slits is slightly increased without changing other parameters.
State the effects, if any, that this change has on:
(i) The separation of the fringes. **(1 mark)**
(ii) The frequency of light. **(1 mark)**

10) a) What is the de Broglie wavelength of a ball of mass 150 g moving at a speed of 50 m/s? $Planck's constant\ h = 6.62x10^{-34} J.s$ **(2 marks)**

b) The laser light used in compact disc player has a wavelength of 7.8x102nm.Calculate the energy of a single photon of this light.

$Speed\ of\ light\ in\ vacuum\ C = 3x10^{8} m/_{s}$ **(2 marks)**

11) A certain simple pendulum has a period on earth of 1.6 s.

a) What is meant by period of 1.6 s of simple pendulum? **(1 mark)**
b) What is its period on the earth surface of Mars, where g=3.71 m/s^2?

(2 marks)

12) Einstein equation for photoelectric effect is given by $hf = \phi + E_k$

What do you understand by each of the terms hf , ϕ and E_K? **(3 marks)**

13) Analyze the figure below which shows how the energy E_k of photoelectrons emitted from the surface of sodium metal varies with frequency f of the incident radiation and answer the questions that follow **(figure 4)**.

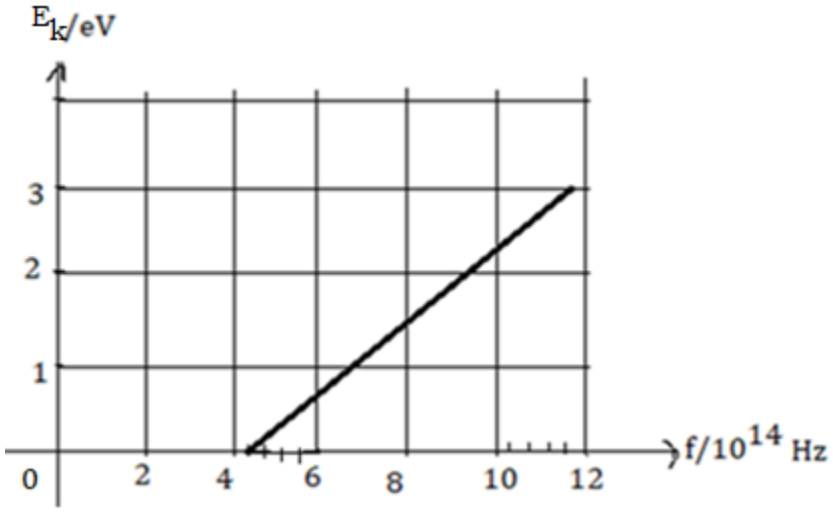


Figure 4

1) Find the threshold frequency **(2 marks)**
2) Calculate the work function of sodium in J or eV **(2 marks)**

14) a) Outline any two examples of renewable energy sources **(2 marks)**

b) State any one example of fossil fuels **(1 mark)**

15) Some waves are longitudinal; some waves are transverse, some waves are electromagnetic; some waves are mechanical. Put ticks in the table below to indicate which of these descriptions apply to the light waves of the lightning and the sound waves of the thunder. **(4 marks)**

	Light waves	Sound waves
Longitudinal		
Transverse		
Electromagnetic		
Mechanical		

Section B: Attempt any three questions **(30 marks)**

16) a)A body of mass m executes simple harmonic motion .

The potential energy, the kinetic energy and the total energy are measured as function of displacement **y.**

(i)What do you understand by the term simple harmonic motion? **(2 marks)**

(ii)Write the expression as function of y of each of the following physical quantities related to the body executing simple harmonic motion

1) Kinetic energy of the body **(1mark)**

2) Potential energy of the body **(1mark)**

3) The total energy of the system **(1mark)**

b) Which of the following statements is true or false?

(i)The kinetic energy is maximum when y =0 **(1mark)**

(ii)The total energy is zero when y=0 **(1mark)**

(iii)The restoring force is maximum at the extreme positions **(1mark)**

(iv)The potential energy is maximum when y is maximum **(1mark)**

(v)The acceleration of the body is maximum at the equilibrium position **(1mark)**

17**)** a) The following phenomena prove that light can behave like either a particle or a wave: Reflection of light, refraction of light, interference of light, photoelectric effect, Compton effect

(i)What phenomena best prove that light is a particle instead of wave? **(2 marks)**

(ii)What phenomena best prove that light is a wave instead of particle? **(3 marks)**

b) When electromagnetic radiation with a wavelength of 350 nm falls on a metal, the maximum kinetic energy of the ejected electrons is 1.20 eV

(i)What is the frequency of this electromagnetic radiation?

The speed of light in vacuum is $3x10^8$ m/s **(2 marks)**

(ii)Determine the work function for this metal in joules then in electron volts

Planck's constant $h=6.626x10^{-34}$ kg m^2/s or $h=6.626x10^{-34}$ Js

(3 marks)

18) a) State any one Kepler's law of planetary motion **(2 marks)**

(b)Explain why values of gravitational potential near to an isolated mass are all negatives **(1 mark)**

c) The orbit of the Earth, mass $6x10^{24}$ kg, may be assumed to be a circle of radius $1.5x10^{11}$ m with the sun at its centre as illustrated in the figure **(figure 5).**

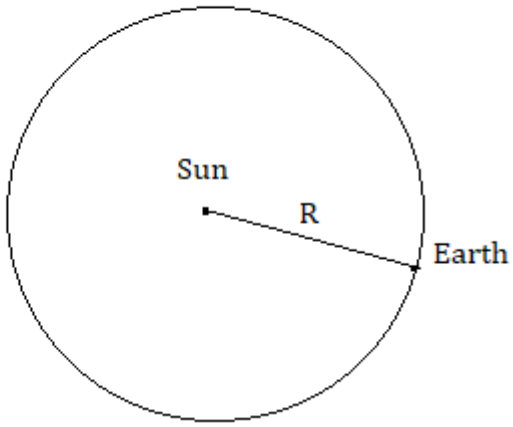


Figure 5

The time taken for one orbit is $3.2x10^7$s

(i)Calculate the magnitude of the angular velocity of the Earth about the Sun **(2 marks)**

(ii)The magnitude of the centripetal force acting on the Earth **(2marks)**

(iii)Determine the mass of the Sun.

Gravitational constant $G=6.67x10^{-11}$ $m^3/kg\ s^{-2}$ **(3 marks)**

19. This is the graph of displacement x against time t for a 0.32 kg object undergoing simple harmonic motion **(figure 6).**

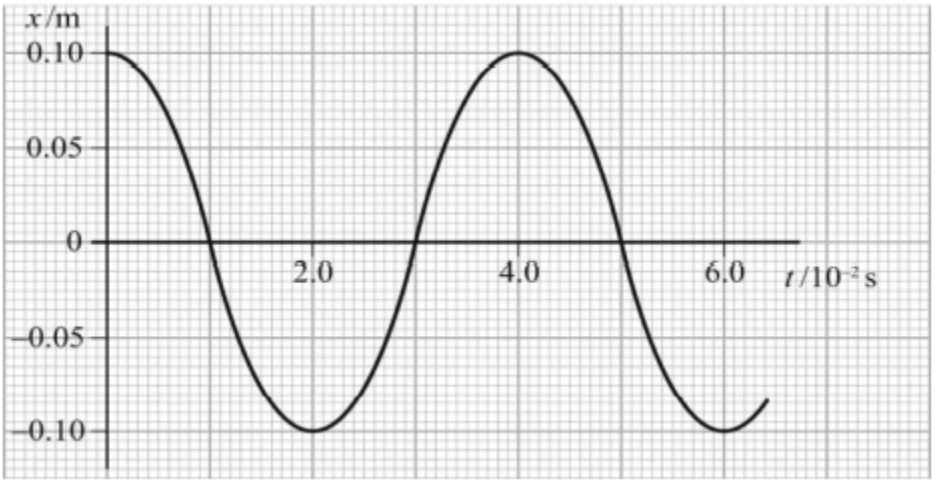


Figure 6

Use the graph to determine the following:

a) The amplitude of the oscillation. **(1 mark)**
b) The period. **(1 mark)**
c) The frequency in hertz. **(2 marks)**
d) The angular frequency in radians per second (rad s−1). **(2 marks)**
e) The maximum speed of the oscillating mass. **(2 marks)**
f) Find the maximum kinetic energy of the object **(2 marks)**

20) Apparatus used to produce interference fringes is shown below.

The apparatus is not drawn to scale **(figure 7).**

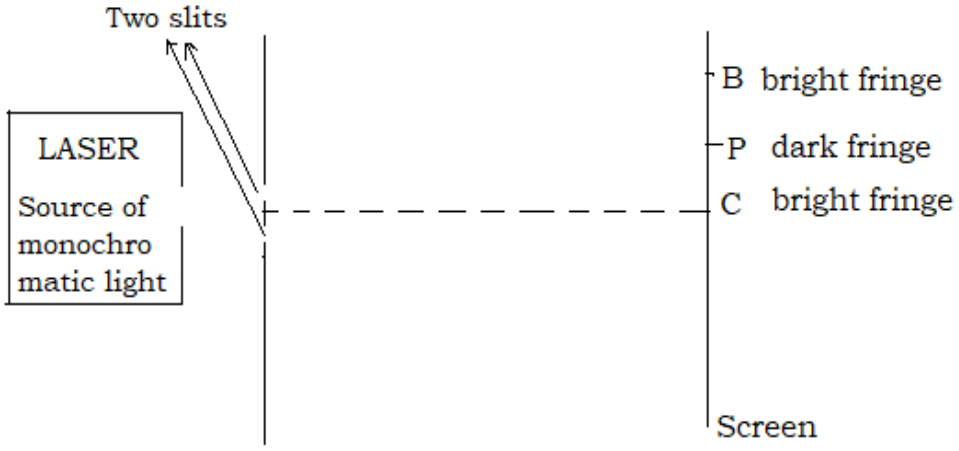


Figure 7

Laser light is incident on two slits. The Laser provides monochromatic light

The light from the two slits produces a fringe pattern on the screen.

A bright fringe is produced at C and the next bright fringe is at B.

A dark fringe is produced at P.

(a)Explain why one laser and two slits are used, instead of two different lasers to produce visible fringe pattern on the screen. **(2 marks)**

(b)State the condition of interference related to the phase difference $\Delta\theta$ between the waves that meet at

1) B **(2 marks)**

2) P **(2 marks)**

(c)State the condition of interference related to the path difference δ between the waves that meet at

1) B **(2 marks)**

2) P **(2 marks)**

Section C: Compulsory question **(15 marks)**

21) A Learner studied the variation in volume with pressure for a sample of air at constant temperature using suitable apparatus. Air can be treated as ideal gas.

The results obtained were recorded in the table below

Pressure P /kPa	Volume V/10^{-5} m^3	$\frac{1}{V}$/ $10^4 m^{-3}$
250.0	1.37	
155.0	1.85	
100.0	2.27	
63.0	2.70	
27.0	3.22	
9.8	3.70	

a) For each value of the volume, calculate 1/V to one decimal place as indicated in the table **(3 marks)**

b) Plot a graph of the pressure P (along vertical axis) against the inverse of the volume $\frac{1}{V}$ (along horizontal axis).

Draw the best fit straight line **(6 marks)**

c)(i)Why the best fit straight line does not pass through the origin?

(1 mark)

(ii) From your graph, state the relation between pressure and volume of a given mass of air. **(1 mark)**

d) Enumerate any two properties of the gas discovered by the student during this experiment. **(2 marks)**

e) Propose two applications of this gas law in daily life **(2 marks)**

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