FORM TP 2022025

TEST CODE **01238020**

JANUARY 2022

CARIBBEAN EXAMINATIONS COUNCIL

CARIBBEAN SECONDARY EDUCATION CERTIFICATE® EXAMINATION

PHYSICS

Paper 02 – General Proficiency

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of SIX questions in TWO sections. Answer ALL questions.
2. Write your answers in the spaces provided in this booklet.
3. Do NOT write in the margins.
4. Where appropriate, ALL WORKING MUST BE SHOWN in this booklet.
5. You may use a silent, non-programmable calculator to answer questions, but you should note that the use of an inappropriate number of significant figures in answers will be penalized.
6. If you need to rewrite any answer and there is not enough space to do so on the original page, you must use the extra lined page(s) provided at the back of this booklet. **Remember to draw a line through your original answer.**
7. **If you use the extra page(s) you MUST write the question number clearly in the box provided at the top of the extra page(s) and, where relevant, include the question part beside the answer.**

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

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NOTHING HAS BEEN OMITTED.

SECTION A

Answer ALL questions.

1. Figure 1 shows the arrangement of the apparatus used to investigate how the pressure of a fixed mass of gas varies with the temperature of the gas.

The cylinder is made of a very strong material which allows it to withstand high pressures and it is sealed so that there are no leaks. A temperature sensor is placed inside the cyclinder to give an accurate record of the temperature of the gas over a wide range of temperatures. A pressure gauge is also placed in the cylinder to record the pressure readings.

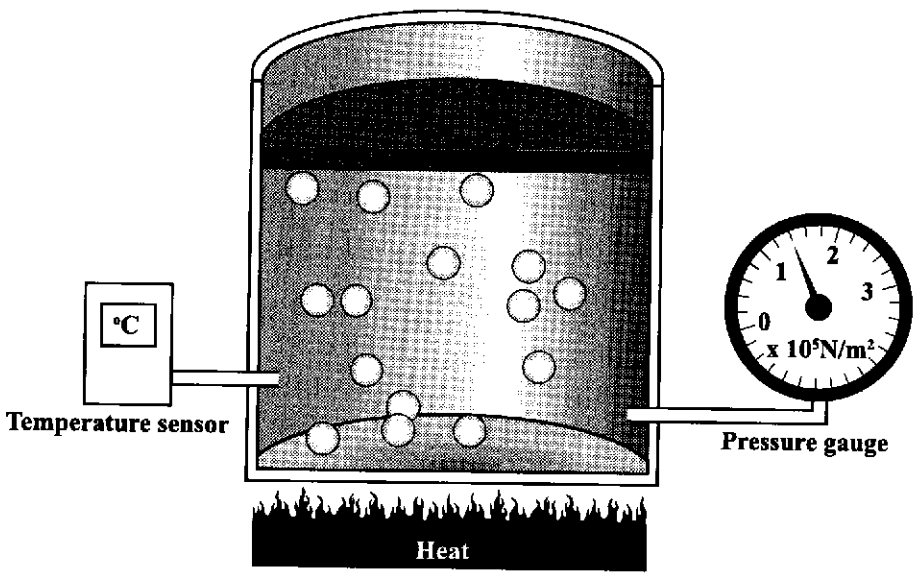

Figure 1. Apparatus used to show the relationship between the pressure and the temperature of a gas

(a) Use the kinetic theory of gases to explain why the pressure of the gas increases as the temperature rises.

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(3 marks)

Table 1 shows the results obtained when the experiment was carried out to investigate the variation of the pressure, P, (Pa) with the temperature, θ, (°C) when the gas was heated.

TABLE 1: RESULTS SHOWING PRESSURE AND TEMPERATURE

Pressure, P ($\times10^5$ Pa)	Temperature, θ (°C)
1.2	25.0
1.3	50.0
1.4	75.0
1.5	100.0
1.6	125.0
1.7	150.0

(b) (i) Use the results from Table 1 to plot a graph of Pressure, P, (Pa) against Temperature, θ, (°C) on the grid provided **on page 7**.

(6 marks)

(ii) Extrapolate the line to meet the temperature axis and mark this point X on your graph. State the temperature value at this point and the name given to this temperature value.

Temperature value at point ....

Name of temperature value ....

(3 marks)

(c) Use the graph to determine the gradient of the line.

(5 marks)

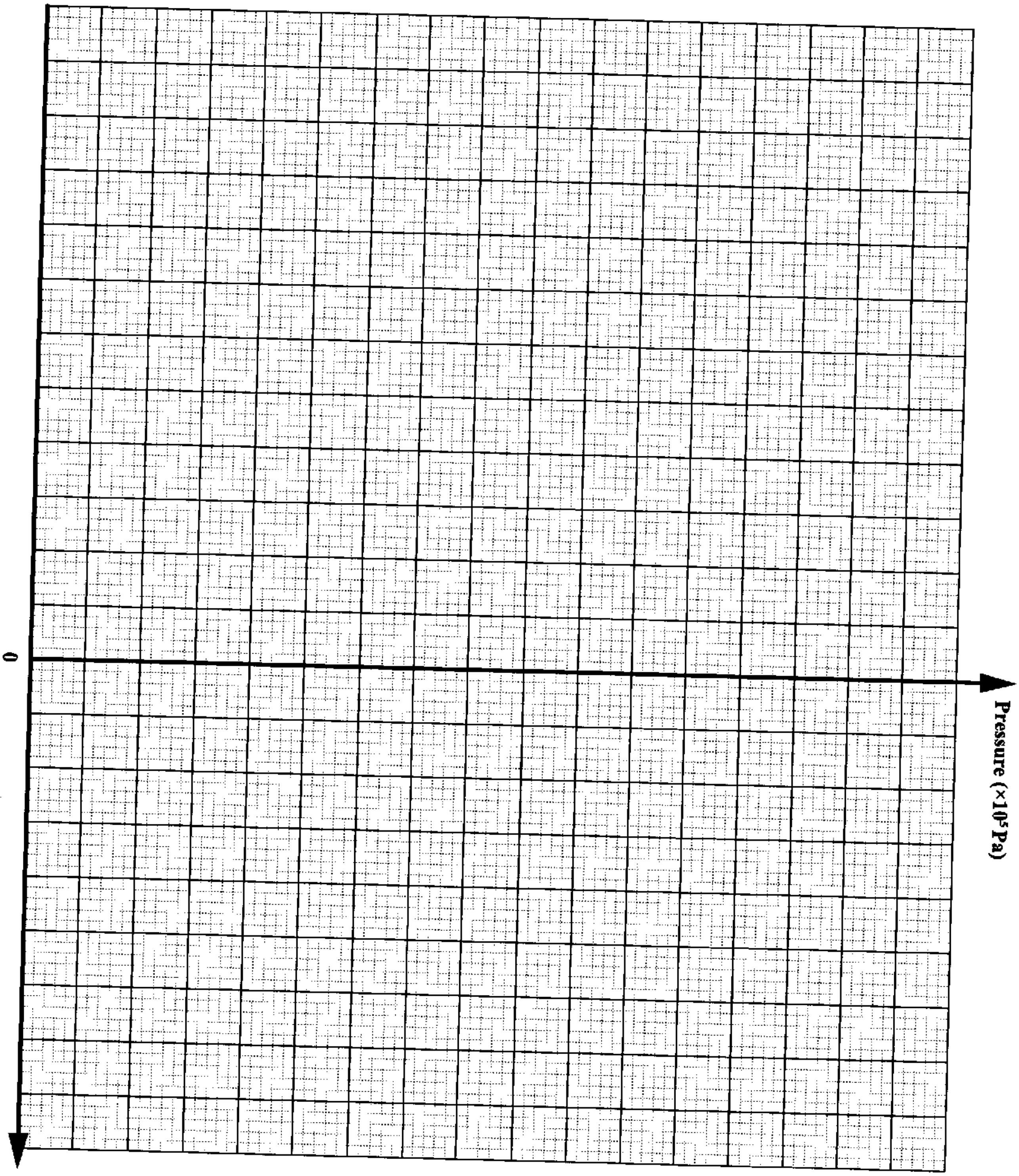

Figure 2. Graph of Pressure, P (Pa) against Temperature, θ (°C)

(d) The sentence below is an incomplete statement of the pressure law. Complete the statement by filling in the blank spaces.

For a .... mass of gas at constant ....

the .... is directly proportional to the ....

temperature of the gas.

(3 marks)

(e) In the experiment, **on page 6**, the pressure of the gas is 1.2×10^5 Pa at a temperature of 25.0 °C. When the cylinder is heated, the pressure reaches 2.1×10^5 Pa. Calculate the temperature of the gas (in °C) at this pressure.

(5 marks)

Total 25 marks

2. Figure 3 shows a sketch of a natural convection solar water heating system.

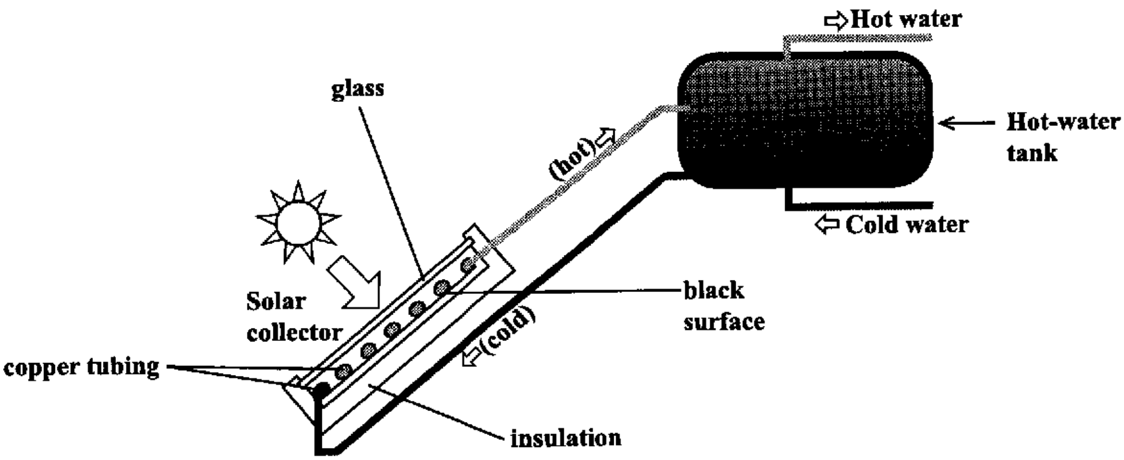

Figure 3. Natural convection solar water heating system

(a) State which feature of the solar water heating system, shown in Figure 3, demonstrates EACH of the following thermal energy principles.

(i) Good absorption of heat

....

(ii) Heat transfer by convection

....

(iii) The greenhouse effect

....

(iv) Good heat transfer by conduction

....

(4 marks)

(b) A group of students used an electrical method to calculate the specific heat capacity of a liquid. The students found that it took 400 s for the temperature of 0.2 kg of the liquid to be raised from 25 °C to 70 °C. The energy supplied by the immersion heater was 15.6 kJ during this period.

(i) Define the term 'specific heat capacity' of a substance.

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(3 marks)

(ii) Calculate the value of the specific heat capacity of the liquid.
Assume that no heat was lost and ignore the heat capacity of the container.

(5 marks)

(iii) Calculate the power rating of the immersion heater.

(3 marks)

Total 15 marks

3. (a) State the TWO laws of reflection.

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(3 marks)

(b) State FOUR properties of an image formed by a plane mirror.

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(4 marks)

(c) Maxwell washed his face at the rest room sink in his favourite restaurant. **Looking into the mirror** he saw the image of the clock on the wall as shown in Figure 4.

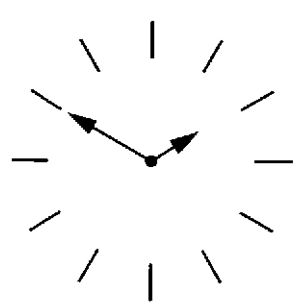

Figure 4. Clock image in the mirror

State the actual time shown on the clock.

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(1 mark)

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(d) The refractive index, n, is defined as the ratio of the speed of light in air to the speed of light in a medium, n = $\frac{V_a}{V_m}$, where m means medium and a means air. Using this definition for the refractive index and the relationship between wavelength, frequency, and speed for a wave, derive the following formula:

$$n_m = \frac{\lambda_a}{\lambda_m}$$

(2 marks)

(e) A beam of green laser light of wavelength 532 nm in air, travels in water. Calculate the wavelength of the laser light in water. (The refractive index of water is 1.33.)

(2 marks)

GO ON TO THE NEXT PAGE

(f) For special effects, a pool designer decides to fix the laser light at the bottom of a pool.

(i) Calculate the critical angle at the water-air boundary.

(2 marks)

(ii) If the angle of incidence of the laser light at the water-air surface is 52°, state what happens to the light at the surface of the pool.

....

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(1 mark)

Total 15 marks

GO ON TO THE NEXT PAGE

SECTION B

Answer ALL questions.

4. (a) (i) Define the term 'linear momentum' and state its SI unit.

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(3 marks)

(ii) State the law of conservation of linear momentum.

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(3 marks)

(b) A truck, of mass 945 kg, heading west on the Sir George Walter Highway slammed head on at 20 ms^{-1} into a car of mass 630 kg, heading east.

(i) Calculate the initial momentum of the truck.

(2 marks)

(ii) If both vehicles come to rest after the collision, calculate the initial velocity of the car.

(4 marks)

(c) The velocity of a car increases from 20 ms^{-1} to 45 ms^{-1} in 10 s. Calculate the acceleration of the car.

(3 marks)

Total 15 marks

NOTHING HAS BEEN OMITTED.

5. Figure 5 shows a solenoid that is connected to a battery with a current, *I*, flowing through it.

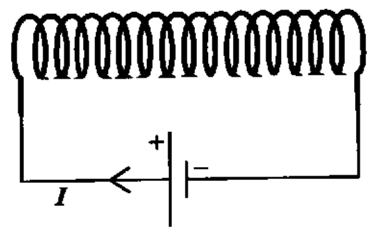

Figure 5. Solenoid connected to a battery

Figure 6 shows a cross–sectional representation of the solenoid shown in Figure 5. The symbol ⊙ represents the current coming *out* of the page and the symbol ⊗ represents the current going *into* the page.

(a) Draw the magnetic field lines inside and around the solenoid on Figure 6.

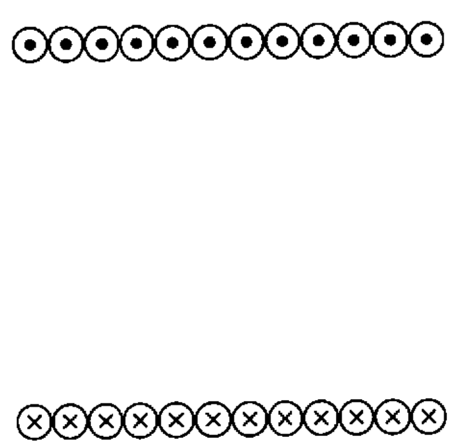

Figure 6. Cross-sectional representation of the solenoid

(3 marks)

(b) The figures below show a constant magnetic field coming out of a surface as indicated by the symbol ⊙.

Figure 7 and Figure 8 show a straight metal wire AB moving across the magnetic field in the direction shown by the arrows, v.

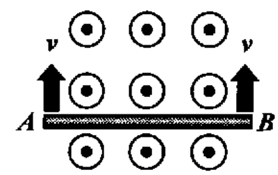

Figure 7. Wire moving across the magnetic field

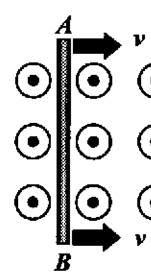

Figure 8. Wire moving across the magnetic field

Figure 9 shows the metal wire moving parallel to the magnetic field (that is, out of the surface).

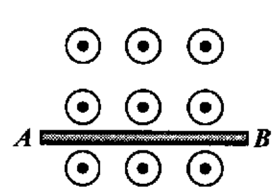

Figure 9. Wire moving parallel to the magnetic field (out of surface)

Complete the table below by stating

(i) the direction of the induced current in the straight metal wire AB

(ii) how the magnitude of the current would change if the speed of the metal wire was doubled.

	Direction of Induced Current in the Metal Wire AB	**Magnitude of Current if Speed was Doubled**
Figure 7		
Figure 8		
Figure 9		

(6 marks)

(c) An ideal step-down transformer is used as part of a power transmission system. It has 1980 turns in its primary coil and 180 turns in its secondary coil.

(i) Calculate the maximum theoretical output voltage if the input voltage is 1320 V.

(3 marks)

(ii) Calculate the input power if a current of 135 A flows in the primary coil.

(3 marks)

Total 15 marks

6. (a) What is meant by the term 'nucleus' of an atom?

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(3 marks)

(b) Radon – 222 is a radioactive nuclide which decays spontaneously with the emission of an alpha particle to form Polonium (Po). The nuclear equation representing the decay of a Radon – 222 nucleus is given below:

$$^{222}_{86}Rn \rightarrow ^{A}_{Z}Po + ^{4}_{2}\alpha$$

(i) State what is meant by the term 'spontaneously'.

....

....

(1 mark)

(ii) Determine the values of A and Z in the nuclear equation above

A: ....

Z: ....

(2 marks)

GO ON TO THE NEXT PAGE

(iii) Use Einstein's mass – energy equation to calculate the energy released during this reaction. **[c = 3.0 × 10⁸ ms⁻¹]**

Masses of the nuclides:

Nuclide	Mass/kg
$^{228}_{86}Rn$	$368.54918 \times 10^{-27}$
$^{A}_{Z}Po$	$361.89489 \times 10^{-27}$
$^{4}_{2}\alpha$	6.64466×10^{-27}

(4 marks)

(c) A fresh sample of Radon – 222 gas, which has a half-life of 3.8 days, was found to have a mass of 240 g.

(i) Define the term 'half-life'.

....

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(2 marks)

(ii) Calculate the mass of Radon – 222 gas remaining after 15.2 days, giving your answer to two significant figures.

(3 marks)

Total 15 marks

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.

EXTRA SPACE

If you use this extra page, you MUST write the question number clearly in the box provided.

Question No. ☐