Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson BTEC Level 3 Nationals Diploma

Centre Number	Learner Registration Number

Tuesday 21 January 2020

Morning (Time: 50 minutes) | Paper Reference **31627H/1P**

Applied Science

Unit 5: Principles and Applications of Science II

Physics

SECTION C: THERMAL PHYSICS, MATERIALS AND FLUIDS

You will need:
A calculator, a pencil and a ruler.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and learner registration number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*

Information

- The exam comprises three papers worth 40 marks each.
  Section A: Organs and systems (Biology).
  Section B: Properties and uses of substances (Chemistry).
  Section C: Thermal physics, materials and fluids (Physics).
- The total mark for this exam is 120.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- The formulae sheet can be found at the back of this paper.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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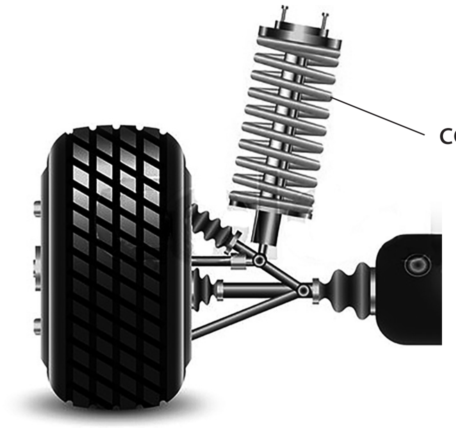
Pearson

Answer ALL questions. Write your answers in the spaces provided.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Figure 1 shows part of a car suspension system.

The coiled spring supports some of the weight of the car.



(Source: ©aarrows/Shutterstock)

Figure 1

The coiled spring is tested by placing it under stress.

(a) Which is the correct unit for stress?

(1)

☐ **A** Nm^{-1}

☐ **B** Nm

☐ **C** Nm^{2}

☐ **D** Nm^{-2}

(b) The coiled spring has an original length of 0.4 m.

When tested, the length of the spring changes by 0.008 m.

Calculate the strain on the spring.

(2)

Use the equation: strain = $\frac{\Delta x}{L}$

Show your working.

strain = ...

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(c) Figure 2 shows the force-extension graph for the coiled spring when tested.

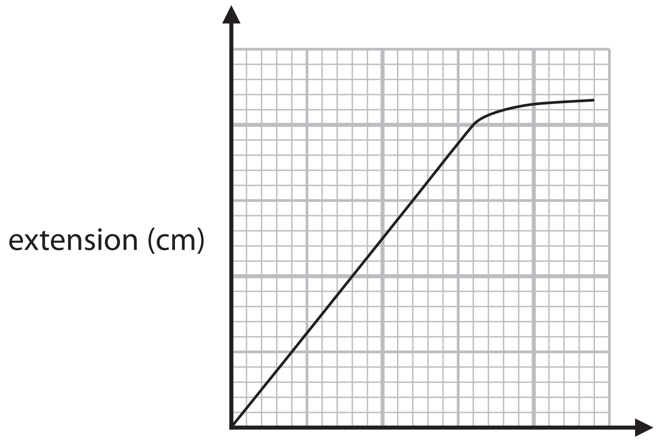

Figure 2

Add an X to Figure 2 to show the elastic limit.

(1)

(d) The coiled spring breaks because of mechanical fatigue.

Which statement correctly describes the cause of mechanical fatigue?

(1)

☒ **A** Repeated loading and unloading.

☒ **B** Slow permanent deformation.

☒ **C** Sudden cracking.

☒ **D** Sudden adding of a large load.

(Total for Question 1 = 5 marks)

2 Water flows along a pipe.

(a) (i) Which factor will affect the viscosity of the water in the pipe?

(1)

☒ **A** density

☒ **B** pressure

☒ **C** temperature

☒ **D** velocity

(ii) Figure 3 shows a pipe that is wide and becomes narrower.

Water flows through the pipe.

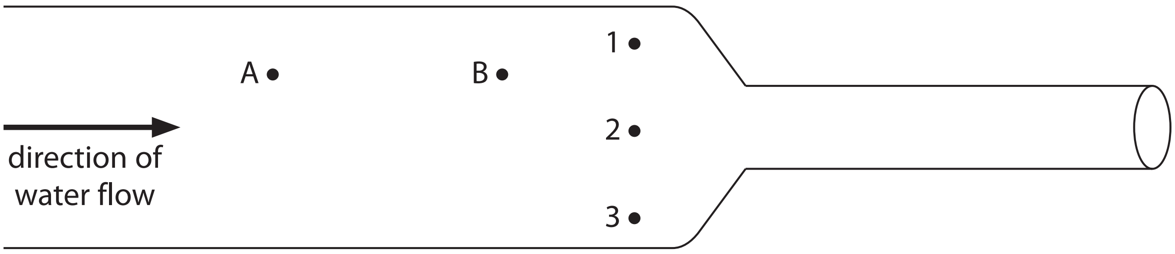

Figure 3

The water in the pipe is moving with a streamline flow.

Complete Paragraph 1 to give a definition of streamline flow.

(3)

There is a steady flow of water in the pipe and the .... of water do not mix.

The velocity of the water at points A and B is the ....

The velocity of the water is greatest at point ....

Paragraph 1

(iii) Explain the effect on the water pressure as the pipe narrows.

(2)

....

....

....

....

(b) Oobleck is a non-Newtonian fluid that is made by mixing cornstarch and water.

Oobleck normally pours like a liquid.

Figure 4 shows a person jumping up and down in a tub containing Oobleck.

When the person jumps on the Oobleck from a height, it acts like a solid.

Figure 4

Explain why the Oobleck acts like a solid when jumped on.

(3)

....

....

....

....

....

(Total for Question 2 = 9 marks)

3 The first law of thermodynamics can be written as an equation, $Q = \Delta U + W$.

(a) (i) Give the meaning of the letter Q in the equation.

(1)

....

(ii) A cylinder of helium gas is used to inflate a balloon.

The helium gas expands into the balloon.

Explain why the temperature of the helium gas does not change if the balloon is inflated slowly.

(2)

....

....

....

....

(b) A sealed cylinder contains helium gas.

The cylinder containing the helium gas is heated.

The cylinder has fixed dimensions.

(i) Which quantity increases for the helium atoms, when the cylinder is heated?

(1)

☒ **A** average density of the atoms

☒ **B** average kinetic energy of the atoms

☒ **C** total number of atoms

☒ **D** volume of each atom

(ii) The gas cylinder contains helium gas at a temperature of 283 K.

The pressure of the gas is 3.0×10^5 Pa.

The volume of the gas remains constant at 0.1 m^3.

The temperature of the helium gas increases to 333 K.

Calculate the new pressure of the gas at 333 K.

(3)

Use the equation: $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Show your working.

pressure = ... Pa

(Total for Question 3 = 7 marks)

4 A petrol engine is an example of a heat engine.

A mixture of petrol vapour and air enters the engine cylinders.

The fuel burns and work is done by the petrol engine.

Figure 5 shows the changes in pressure and volume in one of the engine cylinders.

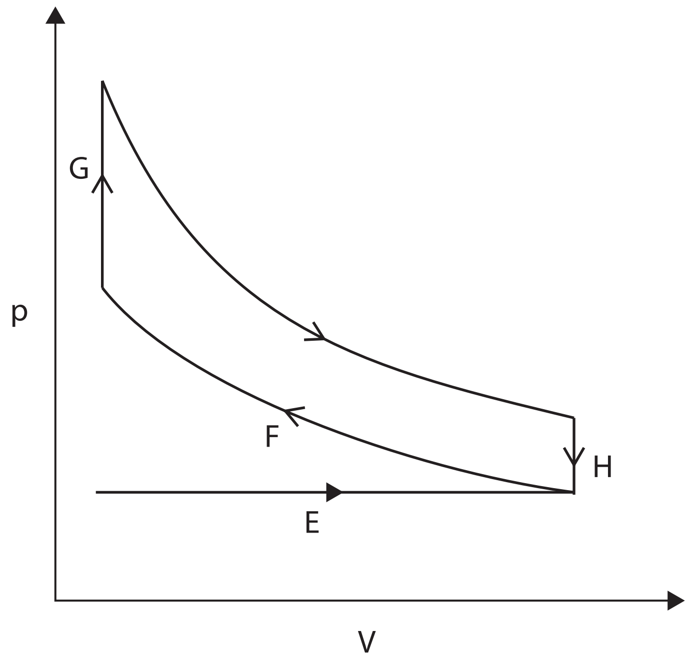

Figure 5

(a) Describe how the pressure in the engine cylinder changes in the four parts E, F, G and H in Figure 5.

(4)

....

....

....

....

....

....

....

....

(b) A fuel-air mixture burns at a temperature of 2800 K.

The engine has a maximum theoretical efficiency of 0.4.

Calculate the output temperature, T_c, of the exhaust gases.

(3)

Use the equation: maximum theoretical efficiency $= 1 - \frac{T_c}{T_H}$

Show your working.

output temperature, T_c = ... K

(Total for Question 4 = 7 marks)

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5 (a) An electric heater is used to heat some water in a shower.

(i) The heater produces 5000 joules of energy every second.

Water enters the heater at a temperature of 289 K.

The mass of water flowing through the heater every second is 0.08 kg.

Calculate the temperature of the water leaving the shower.

(4)

Specific heat capacity of water = 4200 J kg^{-1} K^{-1}

Show your working.

temperature of water = ... K

(ii) The temperature of the water leaving the shower is measured to be different from the calculated value.

Explain why the temperature is different.

(2)

....

....

....

....

(b) A technician takes some ice from a freezer at a temperature of –20 °C.

The technician heats the ice until it has melted and then boiled away.

The technician measures the temperature at regular intervals.

Figure 6 shows a temperature-time graph of the data the technician collected.

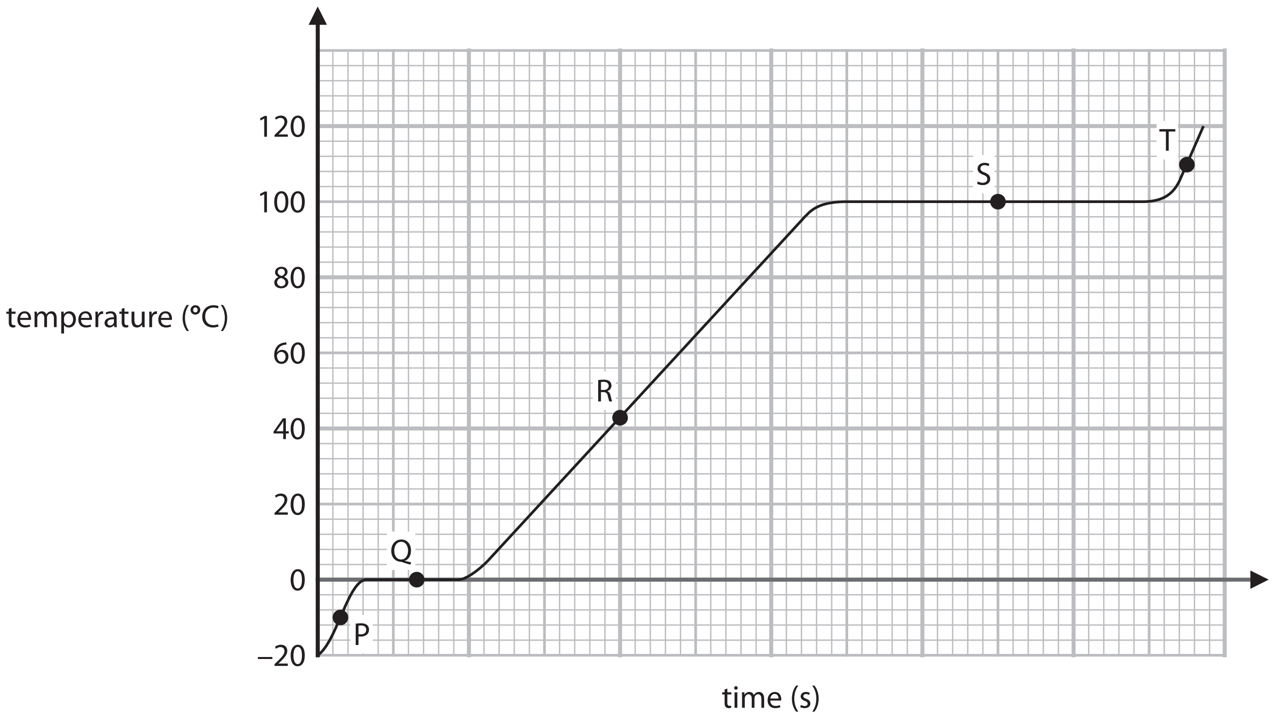

Figure 6

Compare the similarities and differences between the molecules at the points labelled P, Q, R, S and T in Figure 6.

Your answer should include reference to:

- the energy of the molecules
- the intermolecular forces between the molecules.

(6)

(Total for Question 5 = 12 marks)

TOTAL FOR SECTION C = 40 MARKS

Formulae Sheet

Mechanics

Work	$W = F\Delta x$
Work done by a gas	$W = p\Delta V$
Efficiency	$\text{efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}}$
Efficiency for heat engines	$\text{efficiency} = 1 - \dfrac{Q_{out}}{Q_{in}}$
Maximum theoretical efficiency	$\text{efficiency} = 1 - \dfrac{T_c}{T_H}$

Thermodynamics

Ideal gas equation	$pV = NkT$
First law of thermodynamics	$Q = \Delta U + W$
Specific heat capacity	$Q = mc\Delta T$
Specific latent heat	$Q = mL$

Materials

Density	$\rho = \dfrac{m}{V}$
Young modulus	$E = \dfrac{\text{stress}}{\text{strain}}$
	$\text{stress} = \dfrac{F}{A}$
	$\text{strain} = \dfrac{\Delta x}{L}$
Hooke's law	$F = k\Delta x$
Work done in stretching / compressing a wire / spring	$\Delta E = \dfrac{1}{2}F\Delta x$
	$\Delta E = \dfrac{1}{2}k(\Delta x)^2$

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