Write your name here

Surname	Other names

Pearson BTEC Level 3 Diploma

Centre Number

Learner Registration Number

Applied Science

Unit 5: Principles and Applications of Science II

Physics

THERMAL PHYSICS, MATERIALS AND FLUIDS

Wednesday 6 June 2018 – Morning

Time: 50 minutes

Paper Reference

31627H/1P

You must have:
A calculator and 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 is comprised of 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 (a) (i) Work is done on a box when it is lifted from the floor onto a shelf.

Which of these is the same as the work done on the box?

(1)

☒ **A** distance moved by the box

☒ **B** energy transferred to the box

☒ **C** force applied to the box

☒ **D** time taken to move the box

(ii) The box exerts pressure on the shelf.

Identify the unit of pressure.

(1)

☒ **A** kg

☒ **B** kg m^{-2}

☒ **C** N

☒ **D** N m^{-2}

(b) An electric drill has a power output of 0.4 kW.

Give the power output of the drill in watts.

(1)

.....

(Total for Question 1 = 3 marks)

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2 Figure 1 shows water flowing through part of a water pipe that narrows.

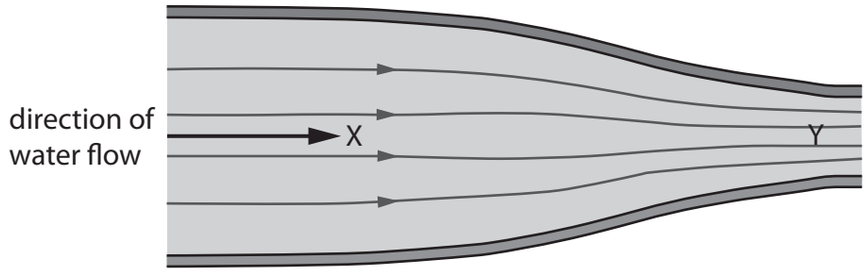

Figure 1

The pressure and velocity of the water flow are measured at point Y and point X.

(a) Which pair of statements is correct for the velocity and pressure at Y compared to X?

(1)

		the velocity at Y compared to X is	**the pressure at Y compared to X is**
☒	**A**	higher	higher
☒	**B**	higher	lower
☒	**C**	lower	lower
☒	**D**	lower	higher

(b) Motor car engines use oil as a lubricant to reduce friction.

The oil needs to reach all parts of the engine to coat all the moving parts.

As the temperature of oil increases it becomes less viscous.

(i) Explain the effects of **low** temperature on how well the oil acts as a lubricant.

(2)

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(ii) Explain the effects of **high** temperature on how well the oil acts as a lubricant.

(2)

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(Total for Question 2 = 5 marks)

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3 (a) (i) A kettle is full of water.

The kettle uses 497 000 J of energy to raise the temperature of the water from 20 °C to 100 °C.

Show that the mass of water in the kettle is approximately 1.5 kg.

Use the equation $Q = mc\Delta T$

Specific heat capacity of water = 4200 J kg^{-1} $°C^{-1}$

Show your working.

(3)

mass of water = ... kg

(ii) The kettle does not switch off when the water starts to boil.

The kettle continues supplying thermal energy until all 1.5 kg of water has boiled away at the same temperature of 100 °C.

Calculate the amount of energy needed to vapourise 1.5 kg of water in the kettle.

Use the equation $Q = \Delta mL$

Specific latent heat of vapourisation of water is 2.26 x 10^6 J kg^{-1}

Show your working.

(2)

energy needed ..... J

(b) (i) A technician heats a metal plate made from cast iron. After a few minutes the temperature of the metal plate is constant when it reaches thermal equilibrium.

Describe what is meant by the term **thermal equilibrium**.

(2)

.....

.....

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.....

(ii) The cast iron plate has a high thermal capacity.

Describe what is meant by the term **thermal capacity**.

(2)

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.....

.....

(Total for Question 3 = 9 marks)

4 (a) (i) State the law of conservation of energy.

(1)

.....

.....

The first law of thermodynamics can be stated as

$$Q = \Delta U + W$$

(ii) State what is meant by the term **W**.

(1)

.....

(b) (i) A student uses the foot pump shown in Figure 2 to inflate a bicycle tyre.

Figure 2

The temperature of the air in the barrel increases as the tyre is pumped up.

The friction in the pump is negligible.

Explain why the temperature of the air in the barrel increases.

(4)

(ii) The barrel of the pump has a volume of 3.8×10^{-4} m^3.

The temperature of the air in the pump is 303 K and exerts a pressure of 2.5×10^5 Pa on the walls of the pump.

Calculate, using the ideal gas equation, the number of molecules of air that are present in the barrel of the pump.

Boltzmann constant $k = 1.38 \times 10^{-23}$ m^2 kg s^{-2} K^{-1}

Show your working.

(3)

number of molecules = ...

(Total for Question 4 = 9 marks)

5 (a) In the manufacture of cars, steel is pressed into panels of different shapes.

Which property of the steel allows the sheets to be pressed into different shapes?

(1)

- ☒ **A** brittleness
- ☒ **B** hardness
- ☒ **C** malleability
- ☒ **D** strength

(b) Car electrical systems use copper.

Copper is described as being ductile.

Explain the term **ductile**.

(3)

(c) Steel bolts are used to hold the engine of a car in place.

One of the steel bolts is stress tested.

(i) The length of the bolt is 10.0 cm before testing.

During the test when the work done on the bolt is 100 J, its length is 10.4 cm.

Calculate the force applied to the bolt when its length is 10.4 cm.

Use the equation

work done in stretching = ½ F Δx

Show your working.

(4)

force applied = ... N

(ii) Figure 3 shows the data from the stress test of the steel bolt.

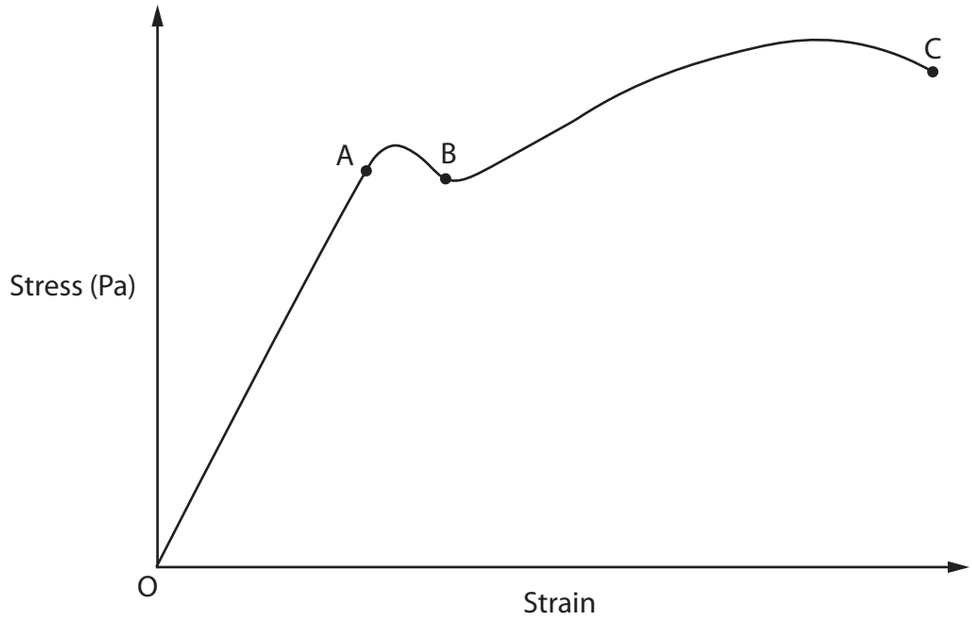

Figure 3

Explain the behaviour of the steel between points:

- O to A

- B to C.

(6)

(Total for Question 5 = 14 marks)

TOTAL FOR PAPER = 40 MARKS
TOTAL FOR EXAM = 120 MARKS

Formulae Sheet

Mechanics

Work	$\Delta W = F\Delta x$
Work done by a gas	$\Delta W = p\Delta V$
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	$E = \dfrac{\text{stress}}{\text{strain}}$
	$\text{stress} = \dfrac{\text{F}}{\text{A}}$
	$\text{strain} = \dfrac{\Delta x}{L}$
Hooke's law	$\text{F} = \text{k}\Delta x$
Work done in stretching/ compressing a wire/spring	$\Delta\text{E} = \dfrac{1}{2}\text{F}\Delta x$
	$\Delta\text{E} = \dfrac{1}{2}k(\Delta x)^2$

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