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 11 June 2019

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

Applied Science

Unit 5: Principles and Application 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 formula 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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P 6 0 4 2 3 A 0 1 1 6

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 An electric motor in a crane does work lifting bricks.

The crane lifts the bricks from the ground to the roof of a building.

(a) Which energy store has increased for the bricks on the roof compared to when the bricks were on the ground?

(1)

☐ **A** elastic potential

☐ **B** electrical

☐ **C** gravitational potential

☐ **D** kinetic

(b) Which unit measures the power of the electric motor in the crane?

(1)

☐ **A** joule

☐ **B** newton

☐ **C** pascal

☐ **D** watt

(c) The electric motor is not 100% efficient.

Explain why the efficiency of the electric motor is less than 100%.

(2)

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(Total for Question 1 = 4 marks)

2 Aeroplanes are designed to reduce the viscous drag of the air they fly through.

Figure 1 shows a prototype aeroplane designed to reduce viscous drag.

Figure 1

(a) Explain how the aeroplane reduces viscous drag.

(2)

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(b) The aeroplane flies from a region of non-turbulent air flow into a region of turbulent air flow.

Complete the diagram in Figure 2 to show how the airflow changes from non-turbulent air flow to turbulent air flow.

(2)

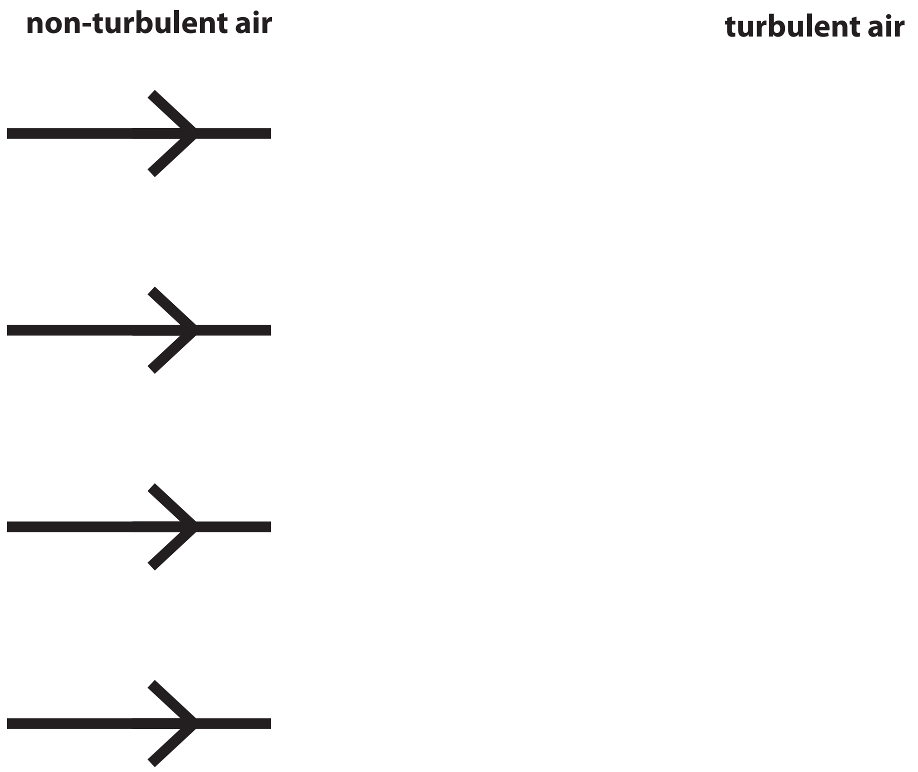

Figure 2

(c) An aeroplane wing is shaped to allow airflow to produce an upward force.

Figure 3 shows a cross-section of an aeroplane wing.

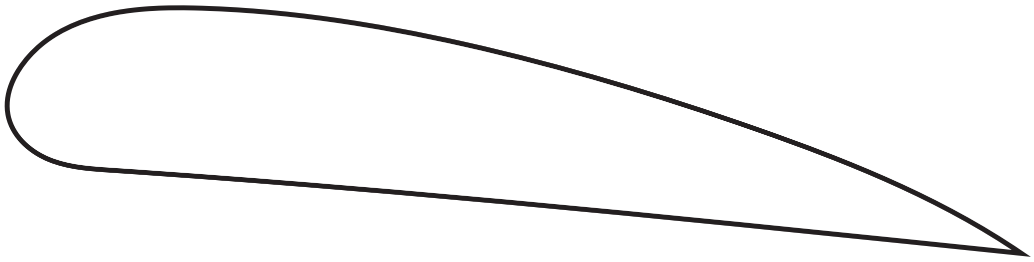

Figure 3

A pressure difference causes the upward force on the aeroplane wing.

Explain why there is a pressure difference.

You may annotate Figure 3 to support your answer.

(4)

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(Total for Question 2 = 8 marks)

3 Steam at a high temperature is compressed in a cylinder by a piston.

(a) (i) Which statement is correct for the steam during compression?

(1)

☒ **A** The kinetic energy of the steam molecules increases.

☒ **B** The mass of steam increases.

☒ **C** The density of the steam decreases.

☒ **D** The number of molecular collisions stays constant.

(ii) The steam is at a pressure of 4.5×10^5 Pa.

The volume of the cylinder changes by $0.3\,m^3$.

Calculate the work done on the steam by the piston.

Assume the steam pressure remains constant.

Use the equation: $W = p\Delta V$

Show your working.

(2)

work done by the piston = ... J

(b) Which type of energy is the sum of all the energy of the steam molecules?

(1)

☒ **A** internal

☒ **B** kinetic

☒ **C** potential

☒ **D** elastic

(c) A kettle of water is boiled next to a window.

Condensation forms on the window when the steam changes into water droplets.

The window is at room temperature.

Describe the behaviour of the water molecules as the steam condenses to form water droplets on the window.

(4)

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(Total for Question 3 = 8 marks)

4 A steel bar must have strength to support heavy loads.

(a) Complete Sentence 1 about the strength of the steel bar.

(1)

When a steel bar has strength, the bar resists ....

Sentence 1

(b) A steel bar is loaded until the steel reaches its yield point.

State **one** change to the structure of the steel at the yield point.

(1)

....

....

(c) A steel bar is stretched with a force of 2.5 kN.

The stress on the steel bar is 3.6×10^5 Pa.

(i) Show that the cross-section of the steel bar has an area of approximately $0.007\ m^2$.

Show your working.

(4)

area of cross-section = ... m^2

(ii) Calculate the strain for the steel bar.

Use the equation: $E = \frac{\text{stress}}{\text{strain}}$

Take the value of Young's modulus, *E*, for steel to be 2.0 x 10^8 Pa.

Show your working.

(3)

strain = ...

(Total for Question 4 = 9 marks)

5 A refrigerator is a type of heat pump.

The contents of a refrigerator are kept at a temperature of 6°C.

(a) Give this temperature in Kelvin (K).

(1)

.... K

(b) The thermal energy taken out of the refrigerator is 4 680 000 J.

The refrigerator has an efficiency of 0.35.

Calculate the input energy to the refrigerator.

(4)

Use the equation: $\text{efficiency} = 1 - \frac{Q_{out}}{Q_{in}}$

Show your working.

input energy = ... J

(c) Figure 4 is a diagram of the cooling system of a refrigerator.

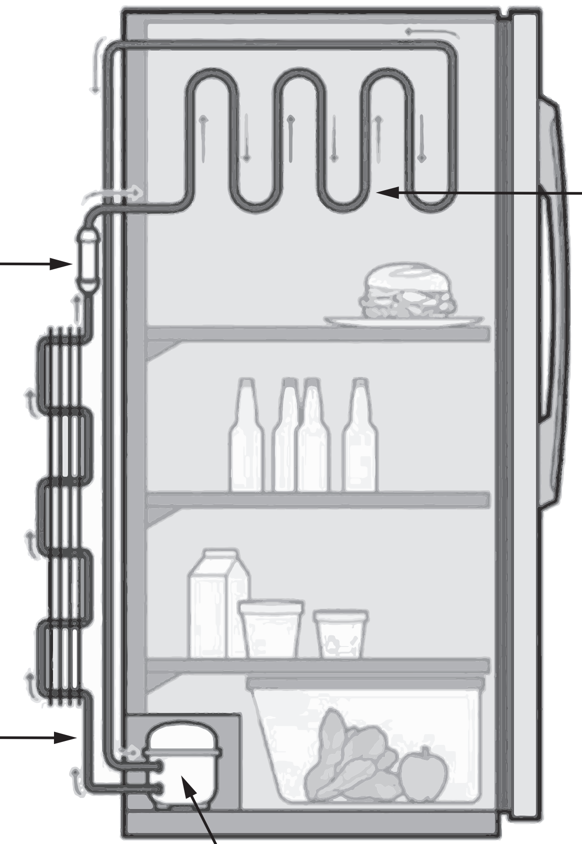

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Figure 4

The refrigerator cooling system consists of four parts:

- compressor
- condenser coils
- expansion device
- evaporator coils.

A refrigerator is an example of a heat pump.

Comment on how the four parts of the refrigerator affect its efficiency as a heat pump.

(6)

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(Total for Question 5 = 11 marks)

TOTAL MARKS FOR SECTION C = 40 MARKS
TOTAL MARKS FOR EXAM = 120 MARKS

Formula 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: $\mathrm{pV = NkT}$

First law of thermodynamics: $\mathrm{Q = \Delta U + W}$

Specific heat capacity: $\mathrm{Q = mc\Delta T}$

Specific latent heat: $\mathrm{Q = mL}$

Materials

Density: $\rho = \dfrac{m}{V}$

Young modulus:

$$E = \frac{\text{stress}}{\text{strain}}$$

$$\text{stress} = \frac{\mathrm{F}}{\mathrm{A}}$$

$$\text{strain} = \frac{\Delta x}{L}$$

Hooke's law: $\mathrm{F = k}\Delta x$

Work done in stretching/ compressing a wire/spring:

$$\Delta \mathrm{E} = \frac{1}{2}\mathrm{F}\Delta x$$

$$\Delta \mathrm{E} = \frac{1}{2}k(\Delta x)^2$$

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