Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson BTEC Level 3 Nationals Diploma, Extended Diploma

Centre Number

Learner Registration Number

Tuesday 19 January 2021

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 must have:
A calculator and a pencil.

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.

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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 the main parts of a refrigerator cooling system.

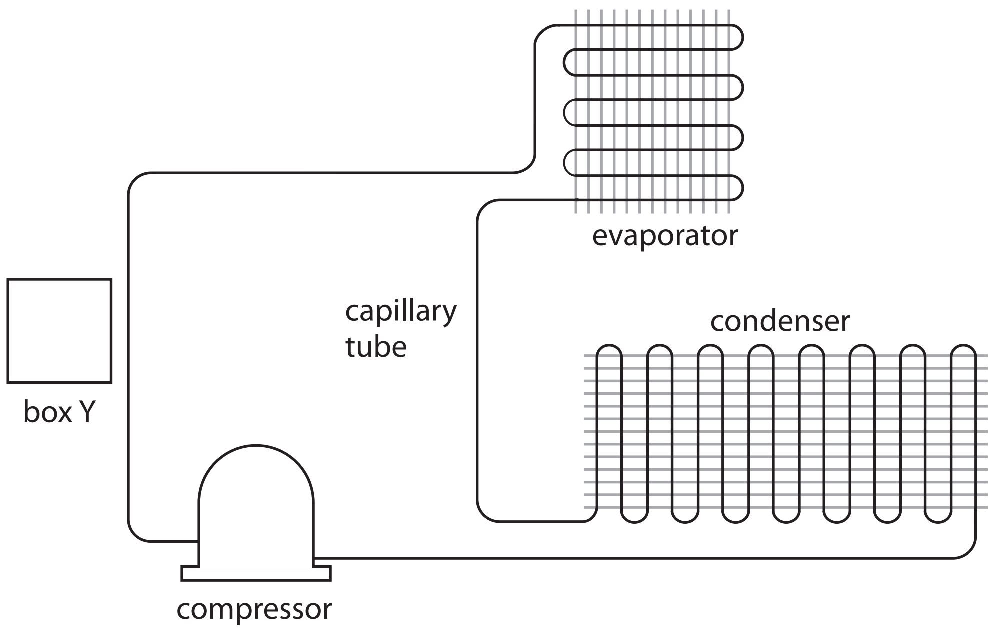

Figure 1

(a) (i) The compressor pumps refrigerant around the cooling system.

Add an arrow to Figure 1 in **box Y** to show the direction of flow of the refrigerant.

(1)

(ii) The refrigerant has a temperature of 2 °C.

Which temperature is 2 °C in kelvin?

(1)

☐ **A** 269 K

☐ **B** 271 K

☐ **C** 273 K

☐ **D** 275 K

(iii) Explain the function of the condenser in Figure 1.

(2)

....

....

....

....

(b) A kitchen has a constant temperature of 300 K.

A refrigerator in the kitchen has a maximum theoretical efficiency of 0.085.

Calculate the temperature inside the refrigerator.

(3)

Use the equation:

$$\text{maximum theoretical efficiency} = 1 - \frac{T_c}{T_H}$$

Show your working.

temperature inside the refrigerator = ... K

(Total for Question 1 = 7 marks)

2 Figure 2 is an image of a racing car.

(Source: © Digital Storm/Shutterstock)

Figure 2

The front of the car has a wedge shape.

(a) Give **two** reasons why this wedge shape allows the car to move as fast as possible.

(2)

1 ....

....

2 ....

....

(b) The car has an aerofoil at the back.

When the car is moving, the aerofoil produces a downward force on the car.

The aerofoil uses Bernoulli's principle.

Figure 3 is a diagram of the cross section through the aerofoil.

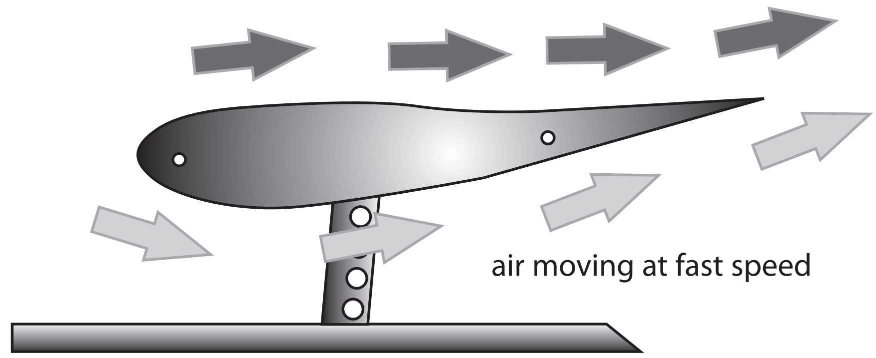

Figure 3

Explain, using Bernoulli's principle, how the aerofoil produces a downward force on the car.

You may add to Figure 3 to support your answer.

(3)

....

....

....

....

....

....

(Total for Question 2 = 5 marks)

3 Figure 4 shows a graph of the stress-strain lines for four different materials, A, B, C and D.

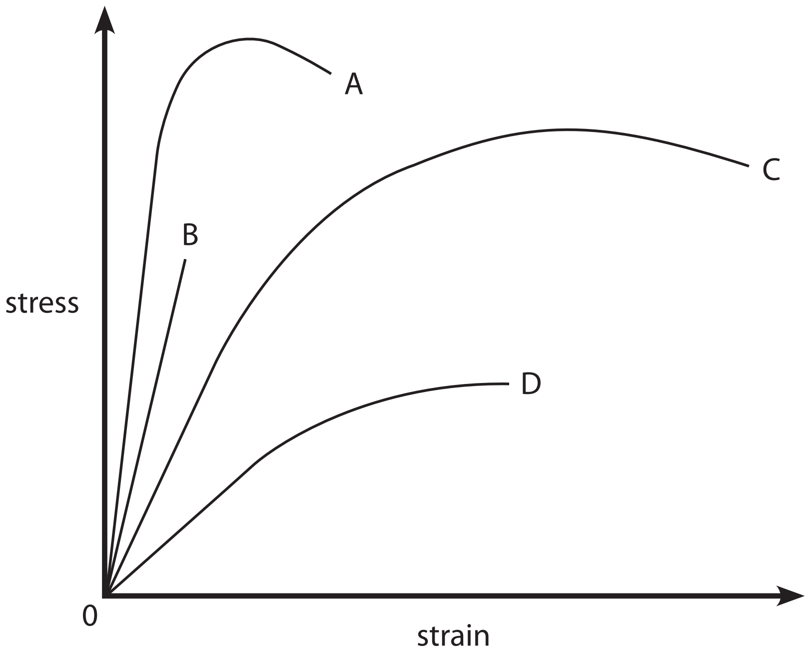

Figure 4

(a) (i) Identify the stress-strain line on Figure 4 for the brittle material.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(ii) Which physical property describes the way some solid materials move slowly and deform permanently with time?

(1)

☒ **A** creep

☒ **B** elasticity

☒ **C** fatigue

☒ **D** malleability

(iii) Modelling clay is a plastic material that can be stretched.

State **one** property of modelling clay that shows it is a plastic material.

(1)

....

....

(b) A piece of thread has a length of 0.500 m.

A force of 2.0 N stretches the thread.

The new length of the thread is 0.505 m.

Calculate the stiffness constant (k) for the thread.

Assume the elastic limit of the thread is not exceeded.

(4)

Use the equation: $F = k\Delta x$

Show your working.

k = ... Nm^{-1}

(Total for Question 3 = 7 marks)

4 A pan of water is heated from room temperature until the water boils.

(a) (i) The temperature of the water increases by 80 K from room temperature to boiling point.

The energy needed to heat the water to boiling point is 5.0×10^5 J.

Calculate the mass of water heated.

(3)

The specific heat capacity of water is 4200 J kg^{-1} K^{-1}

Use the equation: $Q = m\,c\,\Delta T$

Show your working.

mass of water = ... kg

(ii) The water in the pan boils and forms steam.

Explain what happens to the intermolecular structure when water forms steam.

Your answer should refer to intermolecular forces and intermolecular spacing.

(4)

(b) Which is the correct unit for specific latent heat of vapourisation?

(1)

- ☒ **A** $J K^{-1}$
- ☒ **B** $J kg^{-1}$
- ☒ **C** $J K^{-1} s^{-1}$
- ☒ **D** $J kg^{-1} s^{-1}$

(Total for Question 4 = 8 marks)

5 The volume of gas in a cylinder of a petrol engine is 6.0×10^{-4} m^3.

The gas is compressed to a volume of 1.0×10^{-4} m^3.

The average pressure (p) of the gas during compression is 205 000 Pa.

(a) (i) Calculate the work done (W) in compressing the gas at constant temperature.

(3)

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

Show your working.

work done = ... J

(ii) A petrol engine is an example of a heat engine.

Describe what a heat engine does.

(2)

....

....

....

....

(b) In ideal engines, adiabatic and isothermal expansions are reversible and the first law of thermodynamics, $\Delta U = Q - W$, can be applied.

Complete the sentences in Paragraph 1 to give ΔU for each type of expansion.

(2)

In an adiabatic expansion, ΔU = ...
In an isothermal expansion, ΔU = ...

Paragraph 1

(c) Figure 5 shows the pressure-volume (p-V) diagram for the petrol engine cycle.

Table 1 shows the work done in a petrol engine cycle.

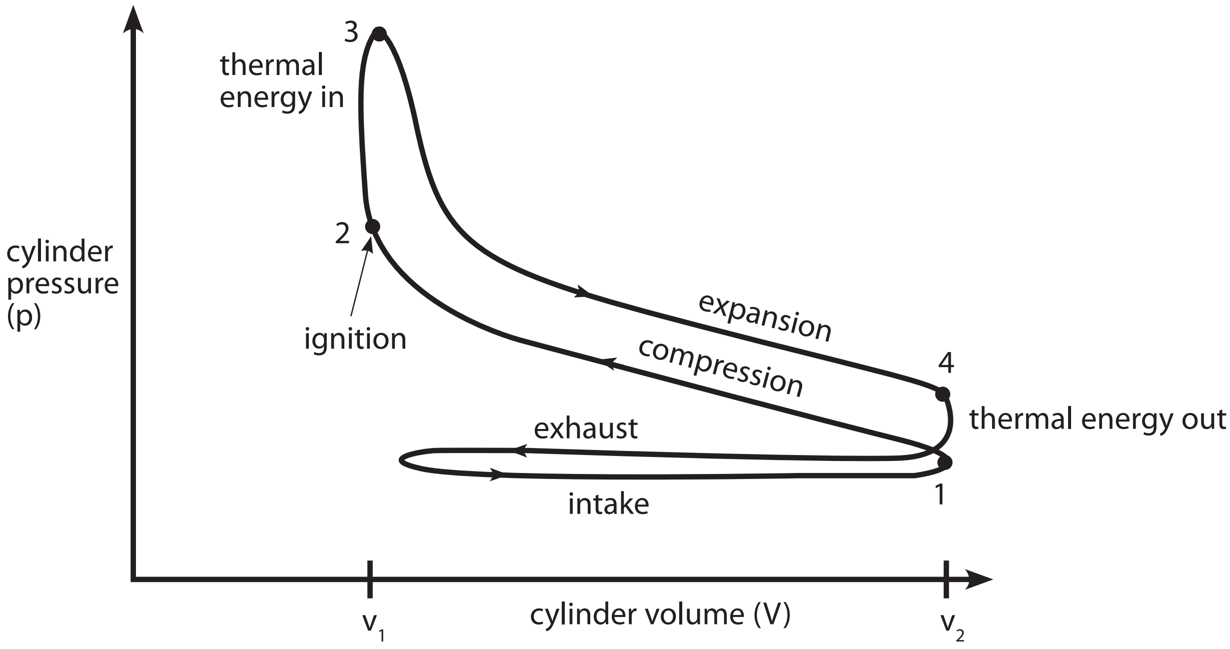

Figure 5

work done	percentage (%)
against friction	25
on intake and exhaust gases	12
by engine	35
in other ways	28

Table 1

Discuss, using Figure 5 and Table 1, the efficiency of an ideal engine cycle and that of the petrol engine cycle.

You may add a diagram of the ideal engine cycle to support your answer.

(6)

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(Total for Question 5 = 13 marks)

TOTAL FOR SECTION C = 40 MARKS

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

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