11 A wet handkerchief is dried in 56 s using a hot iron rated at 2400 W.

Determine whether energy is transferred to the water in the handkerchief at a greater rate than it is transferred to the iron.

initial temperature of wet handkerchief = 18 °C

initial mass of wet handkerchief = 35.9 g

final mass of dry handkerchief = 18.2 g

specific heat capacity of water = 4.19×10^3 J kg^{-1} K^{-1}

specific latent heat of vaporisation of water = 2.26×10^6 J kg^{-1}

(5)

(Total for Question 11 = 5 marks)

18 An old type of camping lamp used a 'gas mantle'. The gas mantle is heated by the gas flame on the lamp and emits a bright white light. Gas mantles used to contain thorium-230.

Thorium-230 decays by alpha emission to form an isotope of radium. A student keeps a radioactive gas mantle in a sealed polythene bag. The student suggests that over a period of a year a significant volume of helium gas will be collected, since an alpha particle is a helium nucleus.

(a) Give reasons why the sealed plastic bag is suitable for collecting the gas.

(2)

(b) A particular gas mantle contains 5.18×10^{-5} g of thorium-230.

(i) Show that the activity of the thorium-230 in the mantle is about 4.0×10^{4} Bq.

230 g of thorium-230 contains 6.02×10^{23} atoms

half-life of thorium-230 = 75 400 years

number of seconds in 1 year = 3.15×10^{7}

(4)

(ii) Determine the volume of helium gas that could be collected in a year as a result of alpha emission.

Assume that the temperature is 22.0 °C and the pressure is 1.00×10^5 Pa.

(4)

Volume = ...

(iii) Calculate the root mean square speed of the atoms in the helium gas at a temperature of 22.0 °C.

(3)

Root mean square speed = ...

(Total for Question 18 = 13 marks)

TOTAL FOR PAPER = 90 MARKS

10 A detector is placed 30 cm from a gamma source, the count rate is 64 counts per minute.

The detector is then placed 60 cm from the source. The background rate is presumed to be a constant 24 counts per minute.

Which of the following gives the expected counts per minute?

☒ **A** 16

☒ **B** 32

☒ **C** 34

☒ **D** 44

(Total for Question 10 = 1 mark)

11 A cup contains 180 g of black coffee at a temperature of 82 °C. 68 g of milk at a temperature of 2.7 °C is added to the coffee. An ideal temperature range for drinking coffee is said to be 50 °C to 60 °C.

Deduce whether the coffee will be within the ideal temperature range when the milk is added.

initial temperature of milk = 2.7 °C

specific heat capacity of black coffee = $4.2 \times 10^3\,J\,kg^{-1}\,K^{-1}$

specific heat capacity of milk = $3.9 \times 10^3\,J\,kg^{-1}\,K^{-1}$

(3)

(Total for Question 11 = 3 marks)

12 Latte is a type of coffee made with hot frothy milk. The milk is heated by pumping steam into it.

Calculate the maximum mass of milk that could be warmed to a temperature of 65 °C by absorbing 15 g of steam at 100 °C.

initial temperature of milk = 4.0 °C
specific heat capacity of milk = 3900 J kg^{-1} K^{-1}
specific heat capacity of water = 4200 J kg^{-1} K^{-1}
specific latent heat of vaporisation of water = 2.3×10^6 J kg^{-1}

Maximum mass = ...

(Total for Question 12 = 4 marks)

14 A student investigated the terminal velocity of steel spheres falling through oil.

The student obtained the following results.

radius of steel sphere = 1.50 mm
volume of steel sphere = $1.41 \times 10^{-8}\,m^3$
mass of steel sphere = $1.10 \times 10^{-4}\,kg$
maximum speed of sphere = $0.849\,m\,s^{-1}$

The student had the following table.

Type of oil	Density at 26 °C / kg m^{-3}	Viscosity at 26 °C / Pa s
Corn	918	0.0447
Hazelnut	918	0.0504
Sunflower	918	0.0414

(a) Identify which type of oil the student used.

(4)

(b) The values in the table are for oil at 26 °C.

Explain the effect of carrying out the investigation with oil at a lower temperature.

(2)

.....

.....

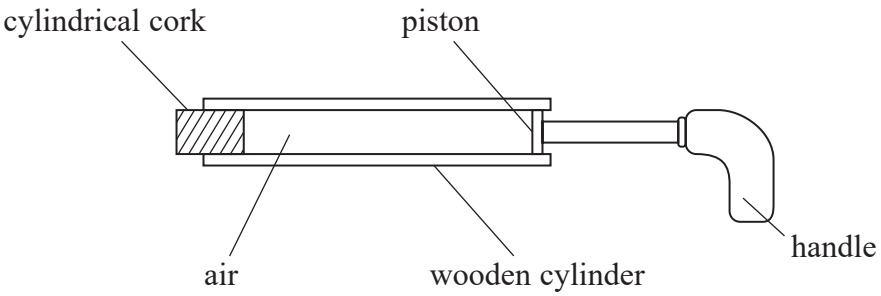
.....

.....

(Total for Question 14 = 6 marks)

18 The photographs show a wooden pop gun before and after the cork is popped.

The diagram shows a cross-section through the pop gun.



Initially the piston is at the right-hand end of the cylinder, as shown. Then the cork is pushed into the other end of the cylinder.

When the handle is pushed in, the pressure of the air in the cylinder increases. This exerts an additional force on the cork.

Once the additional force is sufficient to overcome the frictional force between the cork and the cylinder, the cork is pushed out.

(a) Show that the pressure of the air in the cylinder must be about 2×10^5 Pa in order to push the cork out.

maximum frictional force = 8.8 N
cross-sectional area of cork = 9.2×10^{-5} m^2
atmospheric pressure = 1.0×10^5 Pa

(3)

(b) Calculate the temperature of the gas in the cylinder at the instant the cork is expelled.

volume of air in the cylinder with the handle pulled out = $1.1 \times 10^{-5}\,m^3$
volume of air in the cylinder at the moment the cork is pushed out = $6.7 \times 10^{-6}\,m^3$
atmospheric pressure = $1.0 \times 10^5\,Pa$
initial temperature of air = 19 °C

(2)

Temperature = ...

(c) The formulae sheet for this paper includes the equation

$$pV = \frac{1}{3}Nm\langle c^2\rangle$$

Derive the equation $\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$

(2)

(d) Calculate the root mean square speed of the molecules of air in the cylinder before the handle is pushed in.

average mass of molecule of air = $4.8 \times 10^{-26}\,kg$
temperature of air = 19 °C

(2)

Root mean square speed = ...

(Total for Question 18 = 9 marks)

6 In a particular radioactive decay, there is a mass decrease equivalent to 0.05 u.

Which of the following expressions gives the energy released in MeV?

☒ **A** $\dfrac{0.05 \times 1.66 \times 10^{-27} \times \left(3 \times 10^{8}\right)^{2}}{1.6 \times 10^{-19}}$

☒ **B** $\dfrac{0.05 \times 1.67 \times 10^{-27} \times \left(3 \times 10^{8}\right)^{2}}{1.6 \times 10^{-19}}$

☒ **C** $\dfrac{0.05 \times 1.66 \times 10^{-27} \times \left(3 \times 10^{8}\right)^{2}}{1.6 \times 10^{-13}}$

☒ **D** $\dfrac{0.05 \times 1.67 \times 10^{-27} \times \left(3 \times 10^{8}\right)^{2}}{1.6 \times 10^{-13}}$

(Total for Question 6 = 1 mark)

7 Air is trapped in a glass tube. When the air is forced into a smaller volume at a constant temperature, the pressure increases.

Which of the following statements about air molecules is a reason why the pressure the trapped air exerts on the tube increases?

☒ **A** The molecules have a greater mean kinetic energy.

☒ **B** The molecules make more frequent collisions with each other.

☒ **C** The molecules make more frequent collisions with the walls of the tube.

☒ **D** The molecules experience a greater change in momentum when they collide with the tube.

(Total for Question 7 = 1 mark)

15 Aluminium is one of the most widely recycled metals. Aluminium cans are heated from room temperature until all the aluminium has melted. The molten aluminium is then used to make new cans. This process uses only 5% of the energy needed to extract aluminium from raw materials.

On a website it is claimed that recycling one aluminium can of mass 14 g saves enough energy to listen to music on a mobile phone continuously for 7 days.

Assess the validity of this claim.

melting point of aluminium = 660 K
specific heat capacity of aluminium = 902 J kg^{-1} K^{-1}
specific latent heat of aluminium = 396 kJ kg^{-1}
room temperature = 293 K
mobile phone p.d. = 3.7 V
mobile phone current = 120 mA

(Total for Question 15 = 6 marks)

12 A student placed a metal block of mass 220 g in boiling water at 100 °C for several minutes.

The student then transferred the metal block into 300 g of water at 19 °C inside a glass container of mass 50 g. The final temperature of the water was 23 °C.

The table shows specific heat capacity values for copper and tin.

Metal	copper	tin
Specific heat capacity / J kg^{-1} K^{-1}	390	230

Deduce whether the metal block was made from copper or tin.

specific heat capacity of water = 4200 J kg^{-1} K^{-1}
specific heat capacity of glass = 840 J kg^{-1} K^{-1}

(Total for Question 12 = 5 marks)

14 The fuel used in a camping stove is butane, which is stored in a canister as shown.

Some of the butane in the canister is in a liquid state, and some is a gas.

(a) When the stove uses the butane gas, some of the liquid butane evaporates.

Explain why the temperature of the canister decreases when the stove is used.

(3)

(b) The pressure inside the canister is 220 kPa and the temperature of the gas is 21 °C.

(i) The canister is in the shape of a cylinder of length 0.23 m and radius 0.11 m.

Calculate the number of molecules of butane gas in the canister.

Assume the volume of liquid butane inside the canister is negligible.

(4)

Number of molecules of butane gas = ...

(ii) Calculate the r.m.s. speed of the molecules of butane gas.

mass of butane molecule = 9.6×10^{-26} kg

(2)

r.m.s. speed = ...

(Total for Question 14 = 9 marks)