(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

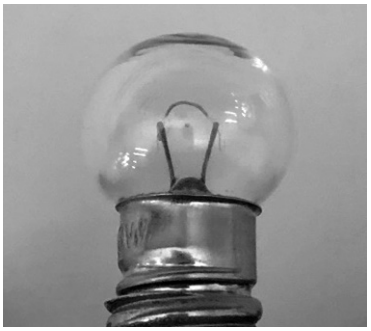
specific heat capacity of black coffee = $4.2 \times 10^3\,J\,kg^{-1}\,K^{-1}$

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

(3)

(Total for Question 11 = 3 marks)

14 The photograph shows a filament bulb.



The filament is an emitter with 35% of the power output of a black body radiator of the same temperature.

(a) When a potential difference (p.d) of 2.0 V is applied across the bulb, there is a current of 0.37 A in the filament.

Calculate the temperature of the filament.

surface area of filament = 3.9×10^{-6} m^2

(3)

Temperature = ...

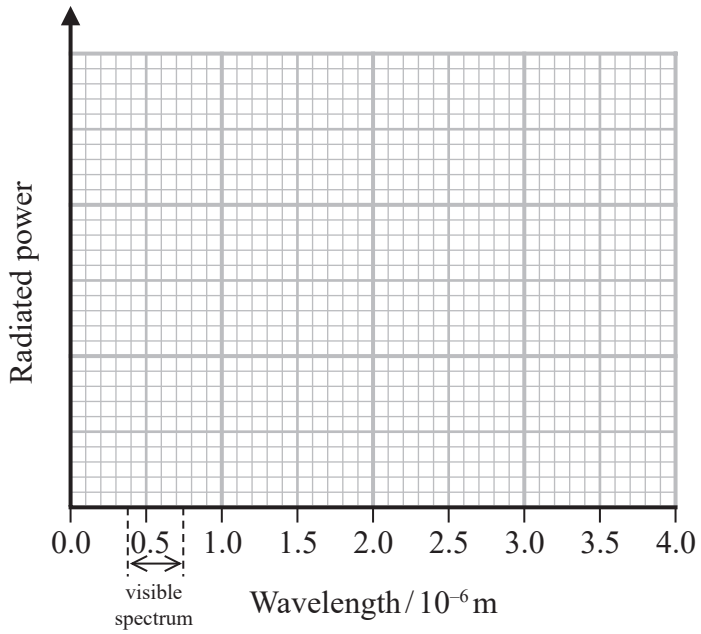
(b) In an experiment to investigate the efficiency of a filament light bulb a p.d. was applied. The p.d. and current were measured and the light bulb was observed. The p.d. was then increased and new measurements taken.

When a small p.d. is applied to the bulb, no light is visible. If the p.d. is gradually increased, the filament starts to glow and eventually appears white.

(i) Add to the graph to show the distribution of radiation from a black body at a temperature of 2026 K.

Your answer should include a calculation.

(5)



(ii) Use your graph to explain why filament light bulbs are considered inefficient.

(2)

(Total for Question 14 = 10 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)

.....

.....

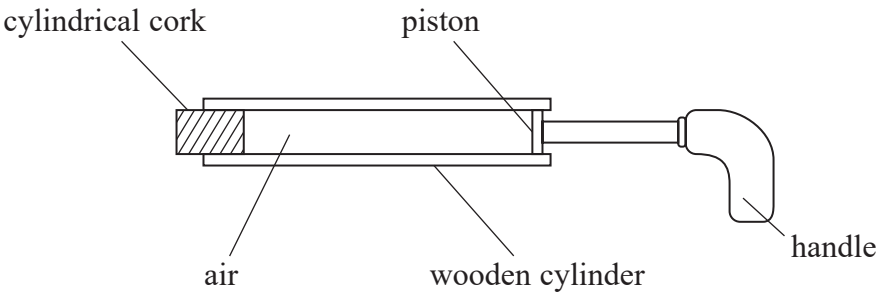
.....

.....

(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)

(Total for Question 3 = 1 mark)

4 Which of the following is a valid unit for luminosity?

☒ **A** $W m^{-2}$

☒ **B** $N m s^{-2}$

☒ **C** $J s^{-1}$

☒ **D** $J m^{-2}$

(Total for Question 4 = 1 mark)

(Total for Question 5 = 1 mark)

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

(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)

19 A fine-beam tube is used for investigating properties of electrons.

An electron beam is produced inside a spherical glass bulb. The bulb contains neon gas at a very low pressure.

(a) The neon gas is at a pressure of 1.25 Pa and a temperature of 25 °C.

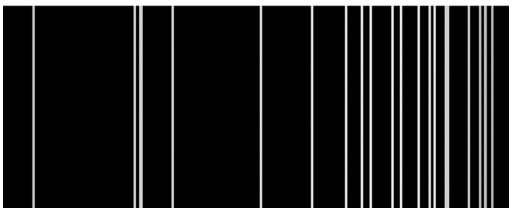
Calculate the number N of neon atoms inside the bulb.

bulb diameter = 16.0 cm

(4)

$N =$ .....

*(b) Interactions between electrons and the neon atoms in the tube make the beam visible. Part of the spectrum of visible light produced by these interactions is shown.



(Source: © MoFarouk/Shutterstock)

Explain the process that results in the emission of this spectrum. Your answer should include reference to energy levels in atoms.

(6)

(Total for Question 19 = 10 marks)