Name: _____

Edexcel_Thermal

Questions

Date:

Time:

Total marks available:

Total marks achieved: _____

Questions

Q1.

The average kinetic energy of the molecules in an ideal gas is

☒ **A** directly proportional to the square root of the absolute temperature.

☒ **B** directly proportional to the absolute temperature.

☒ **C** independent of the absolute temperature.

☒ **D** inversely proportional to the absolute temperature.

(Total for question = 1 mark)

Q2.

Water at 100 °C turns into steam at 100 °C.
Which of the following statements is true?

☒ **A** The internal energy is unchanged, but the kinetic energy of the molecules increases.

☒ **B** The internal energy is unchanged, but the potential energy of the molecules increases.

☒ **C** Both the internal energy and the kinetic energy of the molecules increase

☒ **D** Both the internal energy and the potential energy of the molecules increase

(Total for question = 1 mark)

Q3.

When an ideal gas reaches the absolute zero of temperature, the gas

☒ **A** becomes a superfluid.

☒ **B** condenses to a liquid.

☒ **C** has maximum molecular potential energy.

☒ **D** exerts no pressure.

(Total for question = 1 mark)

Q4. When energy is supplied to a substance, changes in the average molecular kinetic energy (E_k) and the average molecular potential energy (E_p) can occur.

When energy is supplied to an ideal gas

☒ **A** both E_k and E_p increase.

☒ **B** E_k may increase.

☒ **C** E_p may increase.

☒ **D** E_k increases but E_p decreases.

(Total for Question = 1 mark)

Q5.

The absolute temperature scale is a theoretical scale proposed by Lord Kelvin.

On this scale, zero is the temperature at which

☒ **A** all gases become liquids.

☒ **B** an ideal gas would exert no pressure.

☒ **C** the Celsius temperature is −373 °C.

☒ **D** water freezes.

(Total for Question = 1 mark)

Q6.

A data book contains the following information for ethanol.

latent heat of fusion = 109 kJ kg^{-1}

latent heat of vaporisation = 838 kJ kg^{-1}

545 J is transferred from a sample of ethanol when it condenses.

Which of the following shows how to calculate the mass of ethanol that condenses?

(1)

☒ **A** 545 ÷ 109 000

☒ **B** 545 ÷ 838 000

☒ **C** 109 000 ÷ 545

☒ **D** 838 000 ÷ 545

(Total for question = 1 mark)

Q7.

An electric iron rated at 2600 W contains a steel plate which is heated to a working temperature of 215°C. Room temperature is 18°C.

Deduce whether the plate could reach its working temperature in less than 1 minute.

mass of steel plate = 890 g

specific heat capacity of steel = 450 J kg^{-1} K^{-1}

(3)

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(Total for question = 3 marks)

Q8.

A student carries out an experiment to investigate how the volume occupied by a gas depends

upon the temperature.

(a) What variables must the student control in this investigation?

(2)

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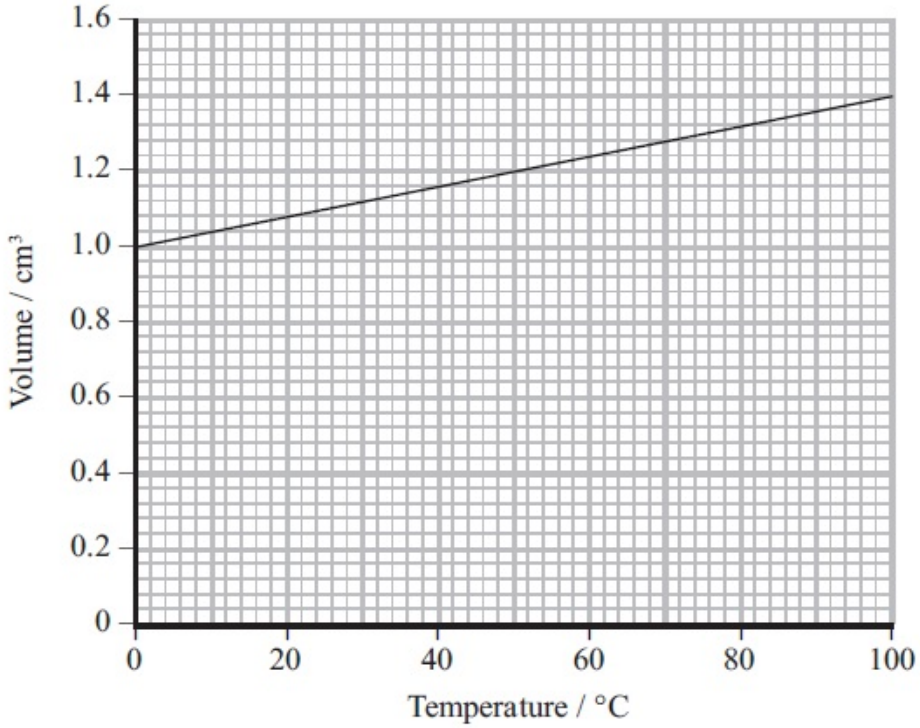
(b) The following graph is obtained.



Explain how graphs such as this provide evidence for an absolute zero of temperature.

(2)

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(Total for question = 4 marks)

Q9.

A car of mass 1200 kg is travelling at a speed of 25 m s^{-1}. During braking, 25% of the kinetic

energy of the car is transferred to the brake pads.

Calculate the increase in temperature of the brake pads.

total mass of brake pads = 5.3 kg
specific heat capacity of brake pads = 450 J kg^{-1} K^{-1}

(4)

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Increase in temperature = ...

(Total for question = 4 marks)

Q10. The heating element of an electric shower has a power of 6.0 kW.

(a) The shower is operated from a 230 V mains supply.

Calculate the resistance of the heating element.

(2)

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Resistance = ...

(b) Water enters the shower at a temperature of 7.5 °C.

Calculate the water flow rate required to give an output temperature of 37.5 °C.

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

(3)

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Flow rate = ...

(Total for Question = 5 marks)

Q11.

(a) Explain what is meant by internal energy of a liquid.

(2)

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(b) A cup of tea contains 175 g of water at a temperature of 85.0 °C. Milk at a temperature of 4.5 °C is added to the tea and the temperature of the mixture becomes 74.0 °C.

(i) Show that the internal energy of the water decreases by about 8 kJ as its temperature decreases.

Specific heat capacity of water = 4200 J kg^{-1} K^{-1}

(2)

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(ii) Calculate the mass of milk that was added to the tea. State an assumption that you have made.

made.

Specific heat capacity of milk = 3900 J kg^{-1} K^{-1}

(3)

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Mass of milk = ...

Assumption

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(Total for question = 7 marks)

Q12.

It is suggested that before making tea in a teapot, the teapot should be warmed by pouring hot water into it. This allows more flavour to be extracted from the tea.

(a) Suggest why a pre-warmed teapot may allow more flavour to be extracted.

(1)

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(b) (i) 0.26 kg of water at 95 °C is added to a stainless steel teapot. In a very short time the teapot and water both reach a temperature of 81 °C.

Show that the energy transferred from the water is about 15 kJ.

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

(2)

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(ii) Calculate the specific heat capacity of stainless steel, stating any assumption you make.

mass of teapot = 0.43 kg
initial temperature of teapot = 22 °C

(3)

Assumption

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Specific heat capacity = ... J kg^{-1} K^{-1}

(iii) The accepted value for the specific heat capacity of stainless steel is about 500 J kg^{-1} K^{-1}. Compare this with the value you have calculated and explain the difference.

(2)

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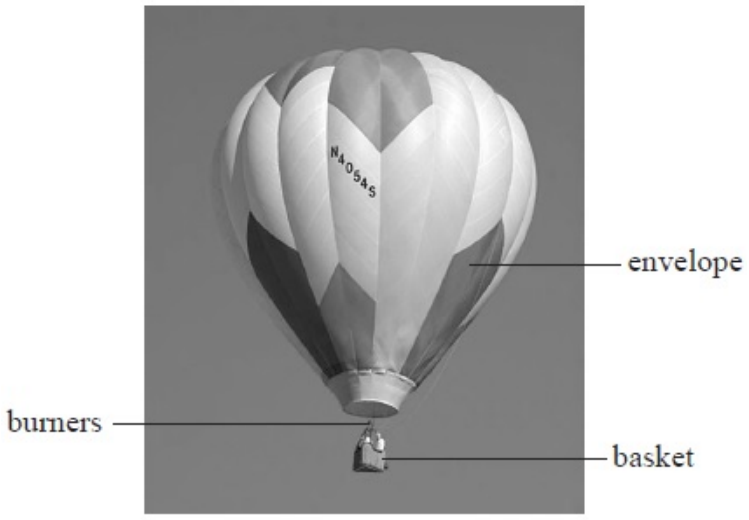
(Total for question = 8 marks)

Q13.

Hot air ballooning is one way to explore the landscape. Air in a balloon is heated from underneath by a set of burners and the balloon starts to rise.



(a) Explain why heating the air causes the balloon to rise.

(2)

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(b) In 1991, Per Lindstrand and Richard Branson become the first people to cross the Pacific in a hot air balloon.

With a volume of 7.4×10^4 m^3 the balloon was, at the time, the largest ever built.

Calculate the energy supplied by the burners to heat the air from 20.0 °C to 35.0 °C.

average density of air in the balloon = 1.20 kg m^{-3}

specific heat capacity of air = 1010 J kg^{-1} K^{-1}

(3)

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Energy = ...

(c) The first balloons used were filled with hydrogen and sealed to keep the volume constant. As the balloon rose there would be changes in the pressure of the hydrogen due to the temperature

changes of the atmosphere.

(i) Calculate the new pressure exerted by the hydrogen if the temperature changed from 20.0 °C to −5.0 °C, as the balloon rose from ground level.

pressure exerted by the hydrogen in the balloon at ground level = 1.01×10^5 Pa

(2)

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New pressure = ...

(ii) State **two** assumptions that you must make to calculate this change.

(2)

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*(iii) By considering the motion of molecules in the gas, explain why the pressure exerted by the gas decreases as it cools.

(3)

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(Total for Question = 12 marks)

Q14.

Electrical power generated by nuclear fission makes an important contribution to world energy needs. However Rutherford, who is credited with the discovery and first splitting of the nuclear

"The energy produced by the breaking down of the atom is a very poor kind of thing. Anyone who expects a source of power from the transformation of these atoms is talking moonshine."

Rutherford carried out experiments that involved firing alpha particles at nitrogen atoms.

(a) (i) Complete the equation for the interaction between nitrogen and alpha particles.

(1)

$$^{14}_{7}\mathrm{N} + ^{4}_{2}\alpha \rightarrow \_\_\mathrm{O} + \_\_^{1}\mathrm{p}$$

(ii) This interaction requires a small energy input. Other similar nuclear reactions may give an energy output of no more than 20 MeV, giving some justification to Rutherford's statement. Suggest why Rutherford's statement eventually turned out to be very inaccurate.

(1)

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(b) Uranium-235 is able to undergo fission when it absorbs a neutron to become uranium-236. The equation below shows a possible fission reaction

$$^{235}_{92}\mathrm{U} + ^{1}_{0}\mathrm{n} \rightarrow ^{92}_{36}\mathrm{Kr} + ^{141}_{56}\mathrm{Ba} + 3 \times ^{1}_{0}\mathrm{n}$$

Use the data in the table to show that the energy released by the fission of one uranium nucleus is about 170 MeV.

Isotope	Mass / 10^{-27} kg
^{235}U	390.29989
^{141}Ba	233.99404
^{92}Kr	152.64708
^{1}n	1.67493

(4)

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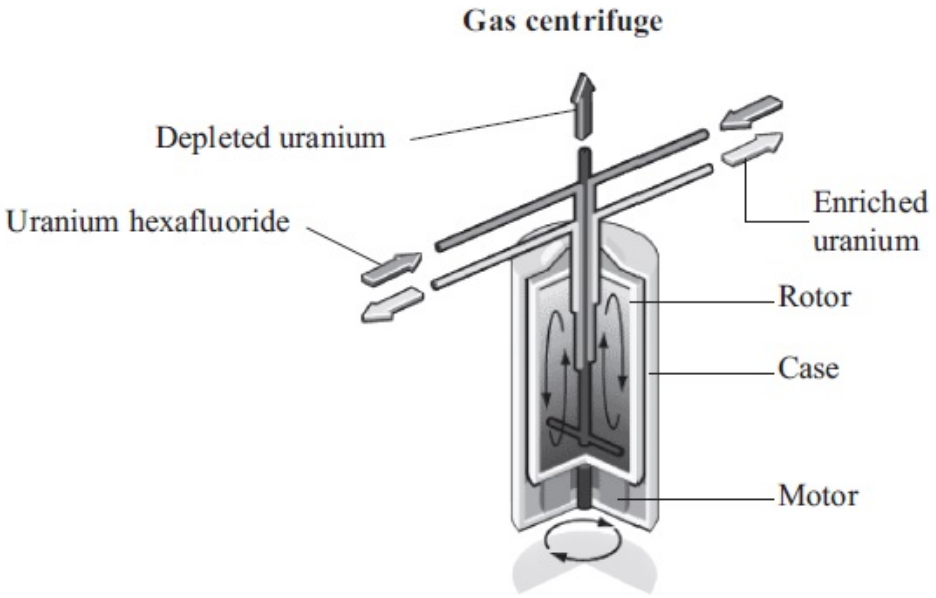
(c) Naturally occurring uranium is more than 99% uranium-238. Fuel for a fission reactor requires at least 3% of the uranium to be uranium-235.

Uranium hexafluoride gas is used during the uranium enrichment process. It is fed into a centrifuge, and a rotating cylinder (rotor) sends the uranium-238 to the outside of the cylinder, where it can be drawn off, while the uranium-235 diffuses to the center of the cylinder.



(i) Give **one** similarity and **one** difference between the nuclei of uranium-238 and uranium-235.

(2)

Similarity

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Difference

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(ii) The rotor has a diameter of 30 cm and spins at a rate of 60,000 revolutions per minute

Calculate the centripetal acceleration at the rim of the motor.

(2)

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Centripetal acceleration = ...

(iii) The rotor is subjected to huge forces because of the high spin rate.

Give **two** mechanical properties essential for the material from which the rotor is made.

(2)

Property 1

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Property 2

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(d) The waste heat from some power stations is transfered to water.

The San Onofre Nuclear Generating Station in California has reactors with a total output power of 2200 MW. These reactors circulate sea water at an average mass flow rate of 7.0×10^4 kg s^{-1}. The water is heated to approximately 11 K above the input temperature as it flows through condensers, before being discharged back into the ocean.

Show that the rate at which energy is removed from the reactors is about 3000 MW, and hence estimate a value for the efficiency of the electrical power generation process.

specific heat capacity of the sea water = 3990 J kg^{-1} K^{-1}

(4)

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Efficiency = ...

(Total for question = 16 marks)