Exampro GCSE Physics

P1 Self Study - Thermal Energy Questions and Markscheme Higher Tier

Name:

Class:

Author:

Date:

Time: 76

Marks: 76

Comments:

Q1. The table gives information about some methods of conserving energy in a house.

Conservation method	Installation cost in £	Annual saving on energy bills in £
Cavity wall insulation	500	60
Hot water tank jacket	10	15
Loft insulation	110	60
Thermostatic radiator valves	75	20

(a) Explain which of the methods in the table is the most cost effective way of saving energy over a 10 year period. To obtain full marks you must support your answer with calculations.

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(3)

(b) Describe what happens to the energy which is 'wasted' in a house.

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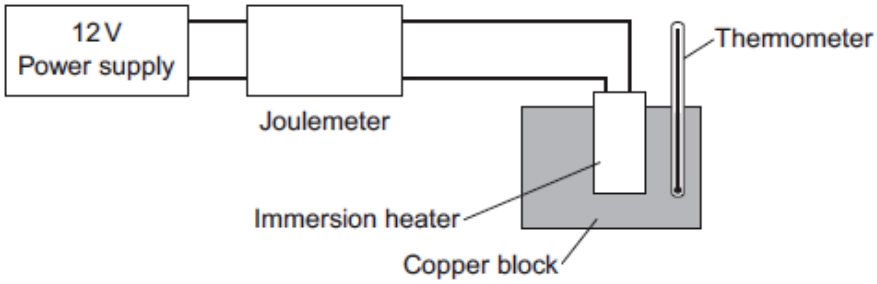
(2)

(Total 5 marks)

Q2. A student used the apparatus in **Figure 1** to obtain the data needed to calculate the specific heat capacity of copper.

Figure 1



The initial temperature of the copper block was measured.

The power supply was switched on.

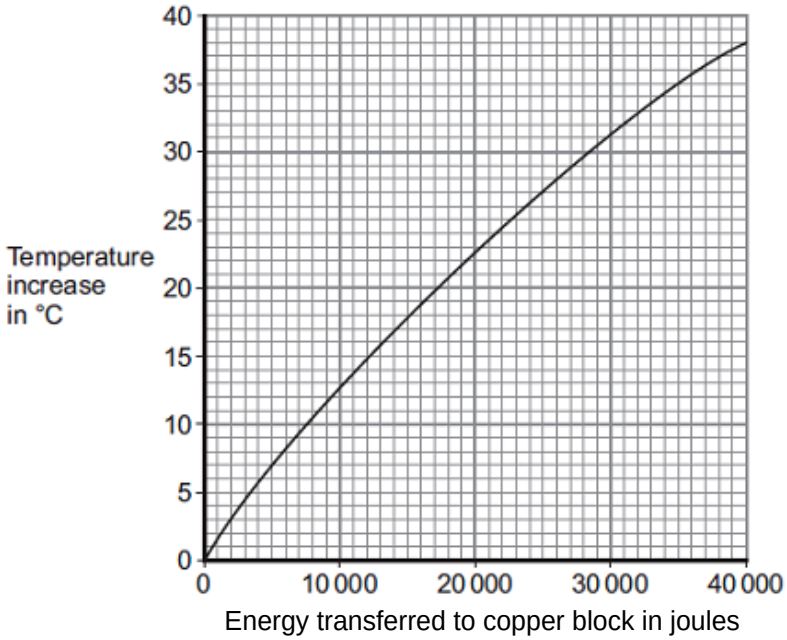
The energy transferred by the heater to the block was measured using the joulemeter.

The temperature of the block was recorded every minute.

The temperature increase was calculated.

Figure 2 shows the student's results.

Figure 2



(a) Energy is transferred through the copper block.

What is the name of the process by which the energy is transferred?

Tick (✓) **one** box.

Conduction ☐

Convection ☐

Radiation ☐

(1)

(b) Use **Figure 2** to determine how much energy was needed to increase the temperature of the copper block by 35 °C.

..... joules

(1)

(c) The copper block has a mass of 2 kg.

Use your answer to part (b) to calculate the value given by this experiment for the specific heat capacity of copper. Give the unit.

Use the correct equation from the Physics Equations Sheet.

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Specific heat capacity = ...

(3)

(d) This experiment does **not** give the correct value for the specific heat of copper.

Suggest **one** reason why.

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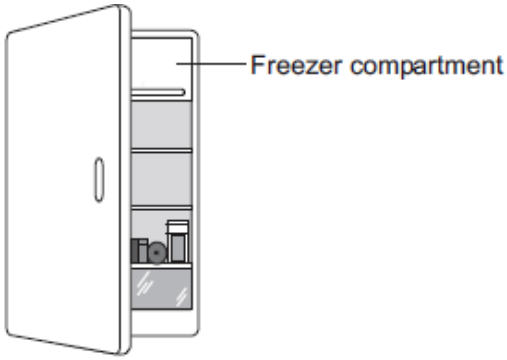
(1)

(Total 6 marks)

Q3. (a) The figure below shows a fridge with a freezer compartment.

The temperature of the air inside the freezer compartment is –5 °C.



The air inside the fridge forms a convection current when the fridge door is closed.

Explain why.

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(4)

(b) The table below shows information about four fridges.

Fridge	Volume in litres	Energy used in one year in kWh
A	250	300
B	375	480
C	500	630
D	750	750

A householder concludes that the energy used in one year is directly proportional to the volume of the fridge.

Explain why her conclusion is **not** correct.

Use data from the table in your answer.

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(2)

(c) New fridges are more efficient than fridges made twenty years ago.

Give **one** advantage and **one** disadvantage of replacing an old fridge with a new fridge.

Ignore the cost of buying a new fridge.

Advantage .....

.....

Disadvantage .....

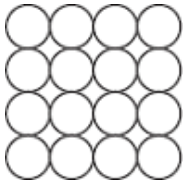
.....

(2)
(Total 8 marks)

Q4. According to kinetic theory, all matter is made up of small particles. The particles are constantly moving.

Diagram 1 shows how the particles may be arranged in a solid.

Diagram 1



(a) One kilogram of a gas has a much larger volume than one kilogram of a solid.

Use kinetic theory to explain why.

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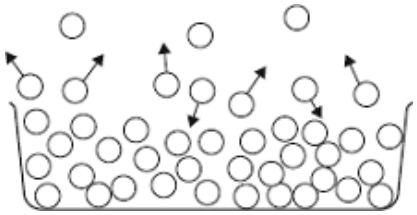
(4)

(b) **Diagram 2** shows the particles in a liquid. The liquid is evaporating.

Diagram 2



(i) How can you tell from **Diagram 2** that the liquid is evaporating?

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(1)

(ii) The temperature of the liquid in the container decreases as the liquid evaporates.

Use kinetic theory to explain why.

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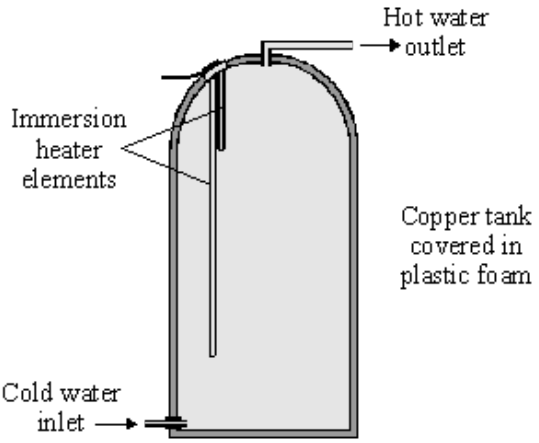
(3)

(Total 8 marks)

Q5. The diagram shows a type of electric immersion heater in a hot water tank. These hot water tanks are normally found in airing cupboards.



Information on the immersion heater states:

230 V
10 A

(a) Immersion heaters for hot water tanks often have a switch on them labelled *bath* or *sink.* The *bath* position of the switch has **both** parts of the immersion heater elements in the circuit. The *sink* position has only the short heater element in the circuit.

(i) Explain why the hot water outlet is at the top of the tank, and the cold water inlet is at the bottom of the tank.

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(2)

(ii) Explain how the *sink* position for the immersion heater is able to save energy.

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(2)

(b) The copper tank is surrounded by plastic foam to minimise energy loss.

Explain why a pale, shiny surface to the foam also helps to minimise energy loss.

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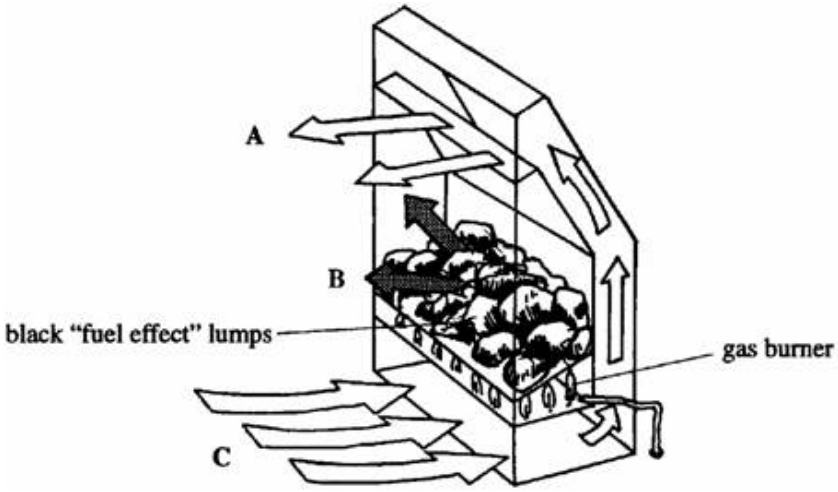
(2)

(Total 6 marks)

Q6. The diagram comes from a leaflet about a "coal effect" gas fire.
It shows how air circulates through the fire.



(a) Explain in detail why the air travels from **C** to **A**.

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(4)

(b) The black “fuel effect” lumps become very hot.

(i) Name the process by which the lumps transfer thermal energy to the room as shown at **B**.

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(1)

(ii) Suggest **one** feature of the black “fuel effect” lumps which make them efficient at transferring energy.

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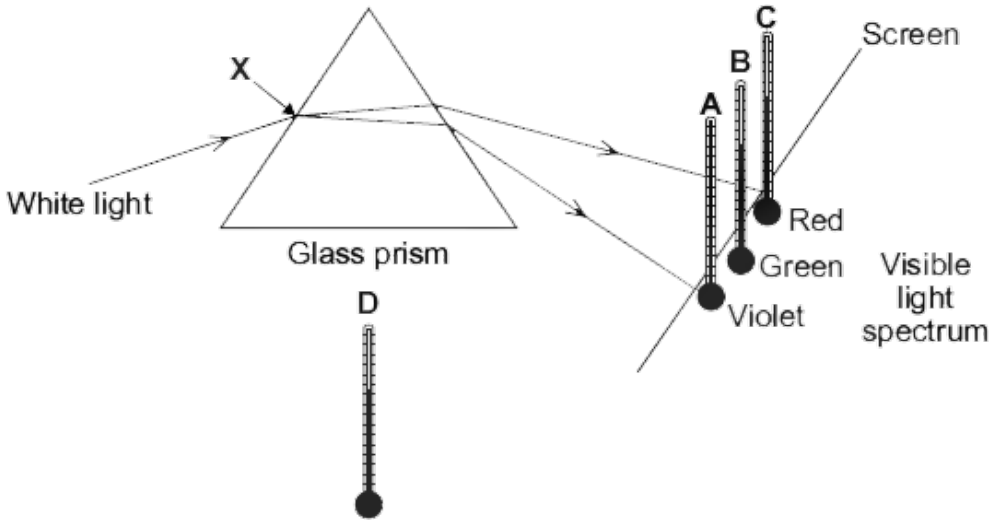
(1)

(Total 6 marks)

Q7. The diagram shows the apparatus that a student used to investigate the heating effect of different wavelengths of light.



(a) (i) What process happens at the point labelled **X** on the diagram?

.....

(1)

(ii) The student put thermometer **D** outside of the light spectrum.

Suggest why.

.....

.....

(1)

(iii) The table gives the position and reading of each thermometer 10 minutes after the investigation started.

Thermometer	Position of thermometer	Temperature in °C
A	in violet light	21
B	in green light	22
C	in red light	24
D	outside the spectrum	20

What should the student conclude from the data in the table?

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(2)

(b) A similar investigation completed in 1800 by the scientist Sir William Herschel led to the discovery of infrared radiation.

Suggest how the student could show that the spectrum produced by the glass prism has an infrared region.

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(2)

(c) A person emits infrared radiation at a frequency of 3.2×10^{13} Hz.

Calculate the wavelength of the infrared radiation that a person emits.

Take the speed of infrared radiation to be 3.0×10^{8} m/s.

Use the correct equation from the Physics Equations Sheet.

Show clearly how you work out your answer.

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Wavelength = ... m

(2)

(d) A thermal imaging camera detects infrared radiation. Electronic circuits inside the camera produce a visible image of the object emitting the infrared radiation.

At night, police officers use thermal imaging cameras to track criminals running away from crime scenes.

Thermal imaging cameras work better at night than during the day.

Explain why.

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(2)

(Total 10 marks)

Q8. Warm air inside a house contains water in the form of a gas. The water condenses onto cold surfaces such as windows. This leaves liquid water on the inside of the glass.

(a) Explain what happens to the particles when water changes from a gas to a liquid.

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(2)

(b) Many houses in the UK have double-glazed windows.

Section through double-glazed window

U-value = 2.8 W/m^2 °C

Section through single-glazed window

U-value = 5.0 W/m^2 °C

Photograph supplied by iStockphoto/Thinkstock

If the window is double-glazed rather than single-glazed there is less condensation on the inside of the glass.

Explain why.

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.....

(2)

(c) Double glazing can be made using two pieces of normal glass with an air gap between them. Better insulating glass (Superglaze or G-type) can be used instead of normal glass. The size of the air gap can also be increased to improve insulation.

A company making double glazing provides some information about their products.

U-values for different types of double glazing

	Normal glass	**Superglaze**	**G-type**
6 mm air gap	3.1	2.7	2.6
12 mm air gap	2.8	2.2	2.0
16 mm air gap	2.7	2.0	1.8

For the same size window, under the same temperature conditions, the energy loss halves if the U-value is halved.

Cost of double glazing in £ per m^2

	Normal glass	**Superglaze**	**G-type**
6 mm air gap	90	110	160
12 mm air gap	100	130	185
16 mm air gap	110	155	210

(i) The data the double glazing company produced is checked and confirmed independently by other scientists.

Suggest why it is important to confirm the data independently.

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(1)

(ii) A homeowner is going to replace his old single-glazed windows with new double-glazed windows.

Discuss the cost of fitting double glazing using better insulating glass compared with double glazing using normal glass.

Use the information given in the tables.

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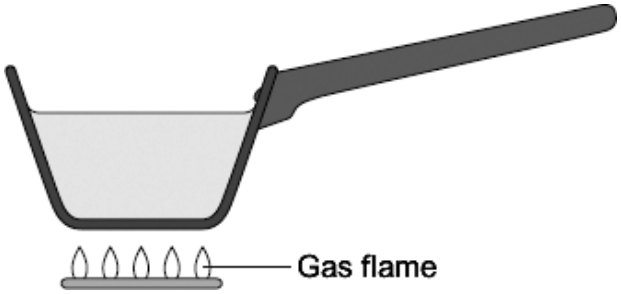
(3)
(Total 8 marks)

Q9. The diagram shows a metal pan being used to heat water.



Energy from the gas flame is transferred through the metal pan by conduction.

Explain the process of conduction through metals.

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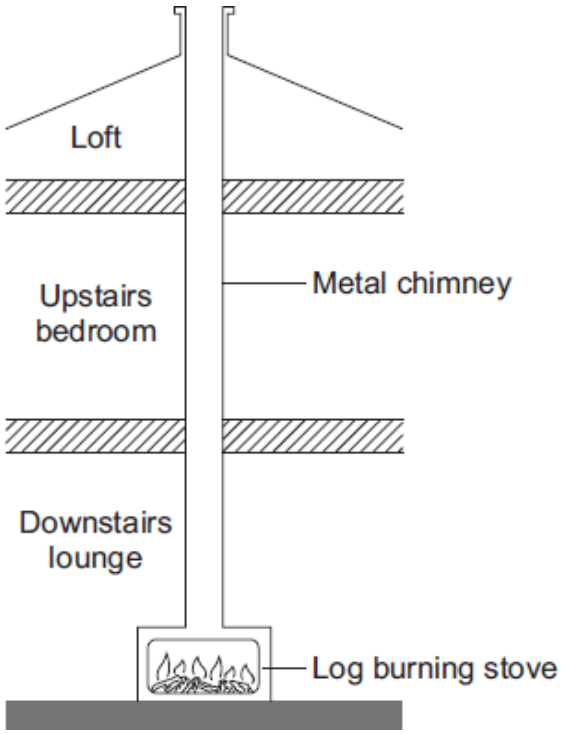
(4)
(Total 4 marks)

Q10. The diagram shows how the metal chimney from a log-burning stove passes through the inside of a house.



(a) Explain how heat is transferred by the process of convection from the inside of the stove to the top of the chimney.

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(2)

(b) Although the outside of the chimney becomes very hot, there is no insulating material around the chimney.

(i) Explain, in terms of the particles in a metal, how heat is transferred by conduction from the inside to the outside of the metal chimney.

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(2)

(ii) Suggest **one** advantage of having no insulation around the chimney.

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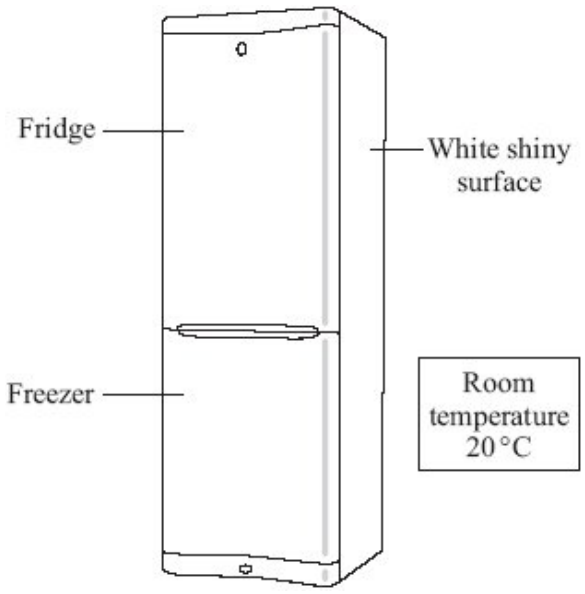
(1)

(Total 5 marks)

Q11. The diagram shows a fridge-freezer.



(a) By which method is heat transferred through the walls of the fridge-freezer?

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(1)

(b) The inside of the fridge is at 4 °C. The inside of the freezer is at –18 °C.

Into which part of the fridge-freezer will the rate of heat transfer be greater?

Draw a ring around your answer.

the fridge **the freezer**

Give a reason for your answer.

.....

.....

(1)

(c) The outside surface of the fridge-freezer is white and shiny.

Give **two** reasons why this type of surface is suitable for a fridge-freezer.

1 .....

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2 .....

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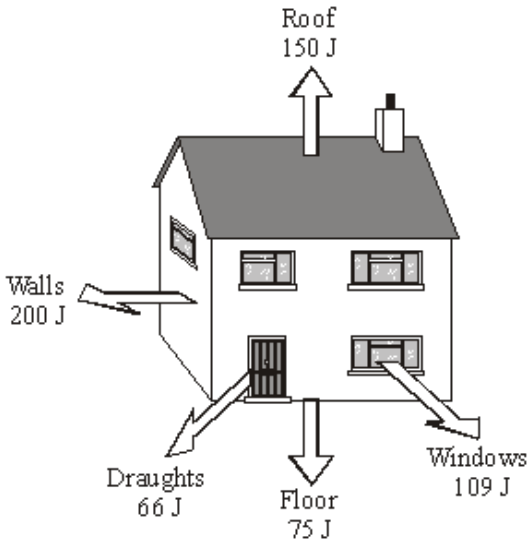
(2)
(Total 4 marks)

Q12. (a) The diagram shows how much heat is lost each second from different parts of an uninsulated house.



(i) Each year, the house costs £760 to heat.

How much money is being wasted because of heat lost through the roof?

Show clearly how you work out your answer.

.....

.....

(2)

(ii) Insulating the loft would cut the heat lost through the roof by 50 %.

The loft insulation has a payback time of $1\frac{1}{2}$ years.

How much did the loft insulation cost to buy?

.....

Cost of loft insulation = £ .....

(1)

(b) What happens to the wasted energy?

.....

.....

(1)
(Total 4 marks)

M1. (a) loft insulation

1

energy saved in 10 years £600

1

net saving (600 – 110) £490

1

OR

hot water jacket

1

energy saved in 10 years £140

1

This is the highest percentage saving on cost

1

(b) transferred to environment / surroundings

1

as heat / thermal energy

1

[5]

M2. (a) conduction

1

(b) 35 000

1

(c) 500

*their (b) = 2 x c x 35 correctly calculated scores **2** marks*
*allow **1** mark for correct substitution,*
ie 35000 = 2 x c x 35
or
their (b) = 2 x c x 35

2

J / kg°C

1

(d) energy lost to surroundings
or
energy needed to warm heater

accept there is no insulation (on the copper block)
*do **not** accept answers in terms of human error or poor results or defective equipment*

1

[6]

M3. (a) air near freezer compartment is cooled or loses energy

accept air at the top is cold

1

cool air is (more) dense or particles close(r) together (than warmer air)

*do **not** allow the particles get smaller / condense*

1

so (cooler) air falls

1

air (at bottom) is displaced / moves upwards / rises

*do **not** allow heat rises*

accept warm air (at the bottom) rises

1

(b) if volume is doubled, energy use is not doubled
or
volume ÷ energy not a constant ratio

1

correct reference to data, eg 500 is 2×250 but 630 not 2×300

1

(c) accept suitable examples, eg

advantage:

- reduces emissions into atmosphere
- lower input power or uses less energy or wastes less energy
- costs less to run

cost of buying or installing new fridge is insufficient

ignore reference to size of fridge

1

disadvantage:

- land fill
- energy waste in production
- cost or difficulty of disposal
- transport costs

1

[8]

M4. (a) there are strong forces (of attraction) between the particles in a solid

accept molecules / atoms for particles throughout
accept bonds for forces

1

(holding) the particles close together

particles in a solid are less spread out is insufficient

1

or

(holding) the particles in a fixed pattern / positions

but in a gas the forces between the particles are negligible

accept very small / zero for negligible
accept bonds for forces

1

so the particles spread out (to fill their container)

accept particles are not close together
gas particles are not in a fixed position is insufficient

1

(b) (i) particles are (shown) leaving (the liquid / container)

accept molecules / atoms for particles throughout
accept particles are escaping
particles are getting further apart is insufficient

1

(ii) *accept molecules / atoms for particles throughout*
accept speed / velocity for energy throughout

particles with most energy leave the (surface of the) liquid

accept fastest particles leave the liquid

1

so the mean / average energy of the remaining particles goes down

1

and the lower the average energy (of the particles) the lower the temperature (of the liquid)

1

[8]

M5. (a) (i) the outlet mark

hot water rises **or** floats up

do not accept heat rises

the inlet mark

1

cold water replacing any drawn off comes in at the bottom and does not mix with hot **or** cool the hot water

do not accept descriptions of a convection current

1

(ii) only heats top (of tank) **or** a small volume

credit heats less water

1

no mixing occurs with cold because hot water is less dense **or** water is a poor conductor

no mixing because cold water is more dense

1

(b) radiation (losses from tank)

do not accept reflection of heat

1

lower from light **or** white **or** shiny surfaces

credit they are poor radiators for both marks

1

[6]

M6. (a) convection

air is heated by the burner / particles gain energy
air expands / particles move about more / particles move faster
air becomes less dense / particles are more spread out
air rises / particles rise - *not* heat rises
air from C moves into the heater / particles from C move into the heater to replace it / them

any four *for 1 mark each*

4

(b) (i) radiation

for one mark

1

(ii) black surface radiates / emits well
(*allow* absorbs and emits well) (*allow* comparison with shiny / white surfaces)

large surface area needed
high temperature (of the lumps)

any one for 1 mark

1

[6]

M7. (a) (i) refraction

accept refracted

reflection, diffraction and dispersion are incorrect

1

(ii) to check rise in temperature (of other thermometers) was due to the (different wavelengths of) light

accept as a control / comparison

to measure room temperature is insufficient

1

(iii) any **two** from three:

- different colours produce different heating effects / (rises in) temperatures
- red light produces the greatest heating effect / (rise in) temperature

or

- violet produces the least heating effect / (rise in) temperature
- all colours produce a greater heating effect than outside the spectrum

an answer

the longer the <u>wavelength</u> the greater the (rise in) temperature

or

the lower the <u>frequency</u> the greater the (rise in) temperature gains both marks

2

(b) move a thermometer into the infrared region / just beyond the red light

allow use an infrared camera / infrared sensor

1

the temperature increases beyond 24(°C)

accept temperature higher than for the red light

1

(c) $v = f \times \lambda$

9.4×10^{-6}

accept 9.375×10^{-6} or 9.38×10^{-6}

or

0.0000094

accept 0.000009375

or *0.00000938*

*allow **1** mark for correct substitution*

ie $3 \times 10^{8} = 3.2 \times 10^{13} \times \lambda$

2

(d) at night the surroundings are cooler

accept at night the air is colder

there is no heat from the Sun is insufficient

or

at night there is a greater temperature difference between people and surroundings

1

(so surroundings) emit less infrared (than in daytime)

accept camera detects a greater contrast

or

gives larger difference in infrared emitted (between people and surroundings)

1

[10]

M8. (a) (kinetic) energy (of the particles) is reduced

accept slow down
accept transfer energy to (cold) glass / surface
accept energy is lost
*do **not** accept vibrate less*

1

move closer together

1

(b) double glazing provides (better) insulation

accept double glazing has a lower U-value
accept less energy / heat transfer through double glazing

1

(inside of) glass is not as cold

accept window stays warm(er)

1

(c) (i) any **one** from:

- to avoid bias
- to make sure results are reproducible
  accept repeatable / reliable for reproducible

1

(ii) any **three** from:

accept Superglaze or G-type for 'better insulating glass' throughout

- the lower the U-value, the better the insulator
  'better insulating glass' has a lower U-value is insufficient
- better insulating glass costs more money
- increasing the (width of) air gap increases cost
- additional cost of better insulating glass offset by energy savings

3

[8]

M9. *accept atoms / particles for ions throughout*

(a metal has) free <u>electrons</u>

accept mobile for free

1

(kinetic) energy of (free) electrons increases

accept energy of ions increases
accept ions vibrate with a bigger amplitude
accept ions vibrate more
*do **not** accept electrons vibrate more*

1

(free) <u>electrons</u> move faster

1

or

electrons move through metal

accept electrons collide with other electrons / ions

(so) electrons transfer energy to other electrons / ions

accept ions transfer energy to neighbouring ions

1

[4]

M10. (a) any **two** from:

- (air) particles / molecules / atoms gain energy
- (air) particles / molecules / atoms move faster
  *do **not** accept move more*
  *do **not** accept move with a bigger amplitude / vibrate more*
- (air) particles / molecules / atoms move apart
- air expands
  ignore particles expand
- air becomes less dense
  ignore particles become less dense
- warm / hot air / gases / particles rise
  *do **not** accept heat rises*
  answers in terms of heat particles negates any of the mark points that includes particles

2

(b) (i) any **two** from

- free / mobile electrons gain (kinetic) energy
  accept free / mobile electrons move faster
  accept vibrate faster for gain energy
- free electrons collide with other (free) electrons / ions / atoms / particles
- atoms / ions / particles collide with other atoms / ions / particles
  answers in terms of heat particles negates this mark point

2

(ii) (faster) energy / heat transfer to room(s) / house
accept room(s) / house gets warm(er)
accept lounge / bedroom / loft for rooms

1

[5]

M11. (a) conduction
*do **not** accept conductor*

1

(b) the freezer
both parts needed

greater <u>temperature</u> difference (between freezer and room)
*do **not** accept because it is the coldest*

1

(c) any **two** from:

- poor absorber of heat / radiation
  accept does not absorb heat poor emitter of heat / radiation is neutral
- reflects heat / radiation (from room away from fridge-freezer)
- reduces heat transfer <u>into</u> the fridge-freezer
- reduces power consumption of fridge-freezer
  *do **not** accept it is a bad conductor / good insulator*

2

[4]

M12. (a) (i) £190
nb mention idea of cost per J in £ will come to an approx figure full credit given
*allow **1** mark for showing that the energy loss through the roof is ¼ of the total energy loss ie 150 / 600*

2

(ii) £142.50

allow ecf 50 % of their (a)(i) × 1.5 ie their (a)(i) × 0.75

1

(b) transferred to surroundings / atmosphere

or becomes spread out

1

[4]