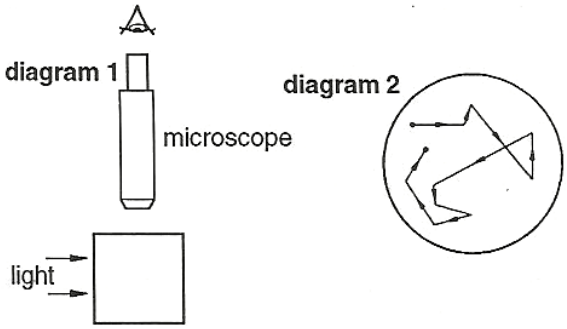
Name: _____ Class: _____ Date: _____

Sec 3 Physics

Worksheet 11: Kinetic Model of Matter, Transfer of Thermal Energy, Temperature & Thermometry

SECTION A: MULTIPLE CHOICE QUESTIONS

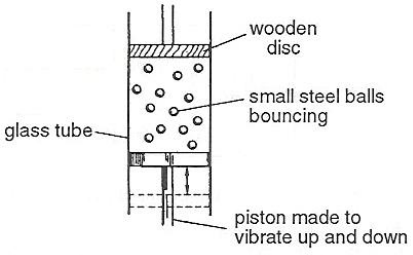
1. Diagram 1 shows smoke particles in a transparent box observed using a microscope. Small points of light are seen to move around, as shown in diagram 2.



What does this experiment demonstrate about air molecules?

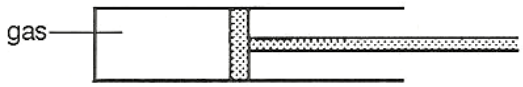
A They are in continuous random motion.
B They can be seen through a microscope.
C They move more quickly when they are heated.
D They move because of collisions with smoke particles.
E They give out light when they collide with smoke particles. ( )

2. The diagram shows a model to demonstrate the behaviour of gas molecules. When the piston is vibrated more rapidly, the wooden disc is forced further up the tube. Weights have to be placed on the disc to return it to its original position. The model represents what happens to a gas when it is



A cooled, then compressed.
B cooled, then heated.
C heated, then compressed.
D heated, then cooled.
E expanded then cooled. ( )

3. The volume of a constant mass of gas in a cylinder is reduced at a constant temperature.



The pressure exerted by the molecules of the gas increases because

A the gas molecules speed up.
B the density of the gas increases.
C the gas molecules collide with each other more often.
D the gas molecules strike the cylinder walls more often.
E there is a smaller area of the cylinder in contact with the gas. ( )

4. A student observes the Brownian motion of smoke particles in the air with a microscope. She sees moving points of light. These points of light come from

A air particles are only moving randomly.
B air particles are only vibrating.
C smoke particles are only moving randomly.
D smoke particles are only vibrating.
E both smoke and air particles moving randomly. ( )

5. Some gas is heated in a sealed container. Which of the following does not increase?

A The force due to the collisions between the gas molecules and the container walls.
B The number of collisions per second by the gas molecules on the container walls.
C The average kinetic energy of gas molecules.
D The average speed of the gas molecules.
E The average distance between gas molecules. ( )

6. Some gas trapped in a cylinder is compressed at constant temperature by a piston. Which of the following will not change?

A Density
B Mass
C Molecular spacing
D Pressure
E Volume ( )

7. When the temperature of a gas rises at a constant volume, its molecules

A move closer together.
B move with greater average speed.
C collide with one another less often.
D exert smaller forces on one another.
E expand. ( )

8. When a solid is heated, which of the following changes occurs?

A The density increases.
B The latent heat increases.
C The melting point increases.
D The molecules vibrate more rapidly.
E The number of molecules increases. ( )

9. Which states of matter are very difficult to compress?

A Gases only
B Gases and liquids only
C Gases, liquids and solids
D Liquids and solids only
E Solids only ( )

10. A fixed mass of gas is heated while kept at a constant volume. How do the properties of the molecules of the gas change?

	Average speed	Frequency of collision with walls	Average distance apart
A	Increases	Increases	Unchanged
B	Increases	Increases	Decreases
C	Increases	Unchanged	Unchanged
D	Unchanged	Increases	Increases
E	Unchanged	Unchanged	Decreases

( )

11. Why does the pressure of a fixed mass of gas increase when it is heated at constant volume?

A More molecules are created by heating.
B The average mass of the molecules increases.
C The average speed of the molecules increases.
D The molecular collisions become more elastic. ( )

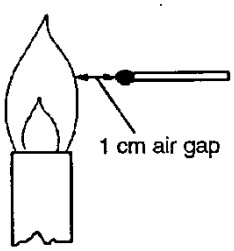
12. The Brownian motion of smoke particles is caused by

A collisions between air molecules.
B collisions between smoke particles.
C collisions between smoke particles and air molecules.
D convection currents in the air. ( )

13. If heat is removed from an object, its temperature will normally

A fall.
B fall, then rise.
C rise.
D rise then fall. ( )

14. An unlit match is held near to a scorching bunsen flame.



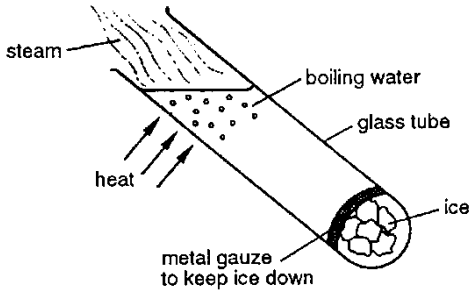
The match does not get hot enough to light because

A the flame is not hot enough.
B air is a bad conductor of heat.
C the match head reflects radiation.
D the flame does not radiate any heat sideways. ( )

15. How may heat be transferred through a vacuum?

A by convection only
B by radiation only
C by conduction only
D by conduction and convection only ( )

16. Boiling water and ice can exist at the same time in a test tube.



What does this experiment show?

A Ice conducts heat well.
B Metal gauze conducts heat poorly.
C Water conducts heat well.
D Water conducts heat poorly. ( )

17. A copper plate is heated to 100 °C. It cools by emitting

A electrons.
B γ – radiation
C infra-red radiation.
D ultraviolet radiation. ( )

18. By what process does a beaker of hot water lose energy?

A conduction, convection and evaporation only
B conduction, convection and radiation only
C conduction, convection, evaporation and radiation
D evaporation and radiation only ( )

19. Which types of surface are the best absorbers and the best emitters of infra-red radiation?

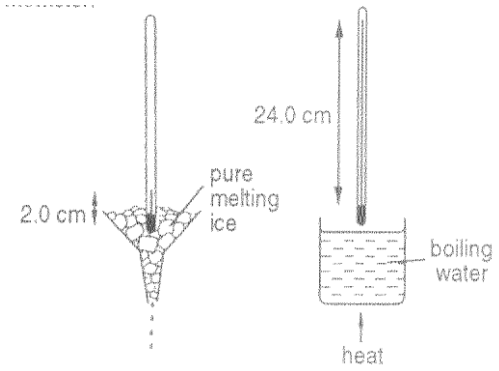
	Best absorber	**Best emitter**
A	black and dull	black and dull
B	black and shiny	white and dull
C	white and dull	black and shiny
D	white and shiny	white and shiny

( )

20. When you stand in bare feet with one foot on a stone floor and the other on a carpet, the stone floor feels colder than the carpet. The most likely explanation is that

A air is unable to circulate through the carpet fibres.
B more energy flows from the carpet to your foot than from the stone floor to your foot.
C more energy flows from your foot to the stone floor than to the carpet.
D the stone floor is at a lower temperature than the carpet. ( )

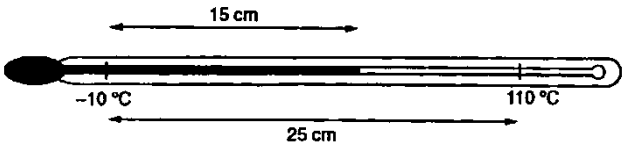
21. The diagram shows the positions of the mercury threads in a thermometer.



What is the distance between each 1 °C mark on the thermometer?

A 0.22 cm
B 0.24 cm
C 2.0 cm
D 2.2 cm ( )

22. The diagram shows a mercury-in-glass thermometer. The distance between the –10 °C and the 110 °C markings is 25 cm.



At which temperature is the end of the mercury thread 15 cm from the -10°C mark?

A 50 °C
B 60 °C
C 62 °C
D 72 °C ( )

23. The lengths of mercury thread in the uniform tube above the bulb of a mercury thermometer are:
20 mm when the bulb is in melting ice;
170 mm when the bulb is in the steam above boiling water;
50 mm when the bulb is in a liquid X.

What is the temperature of liquid X?

A 20 °C
B 25 °C
C 30 °C
D 33.3 °C ( )

24. A thermometer reads 1 °C in pure melting ice and 101 °C in the steam above boiling water. It is used to measure the temperature of the water before and after it is heated.

What is the error when the temperature rise is calculated?

A 2 °C too low
B 1 °C too low
C zero
D 1 °C too high ( )

25. How can the sensitivity of a liquid-in-glass thermometer be increased?

A use a liquid that is a better conductor of heat
B use a thinner-walled bulb
C use a longer tube
D use a liquid of higher boiling point
E use a tube with a narrower bore ( )

SECTION B: STRUCTURED QUESTIONS

1. **(a)** Describe the kinetic theory of matter.

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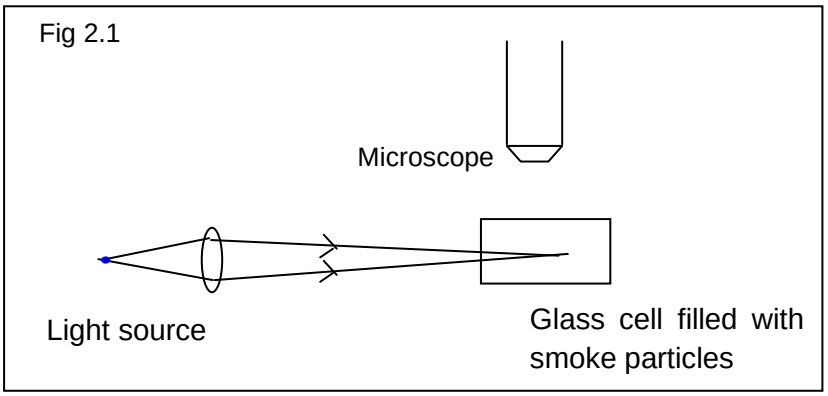
..... [2]

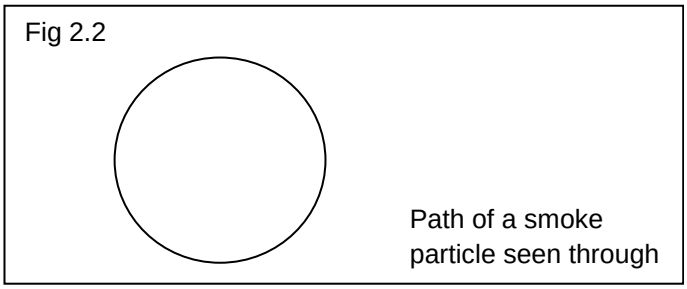
(b) The apparatus below is used to view the Brownian motion exhibited by smoke particles.

Fig 2.1



(i) Sketch the path of one smoke particle seen through the microscope in Fig 2.2 below. [2]

Fig 2.2



(ii) Describe what is seen through the microscope.

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..... [2]

(iii) How do the observations provide evidence for the kinetic model of matter?

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..... [2]

(iv) If the experiment is conducted at a lower temperature, how would the observations be different?

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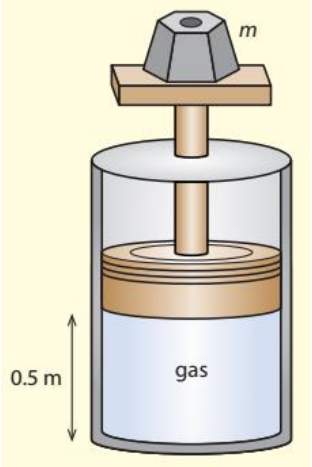
..... [1]

2. The diagram shows a cylinder in a vacuum, which has a movable, frictionless piston at the top. An ideal gas is kept in the cylinder. The piston is at a distance of 0.500 m from the bottom of the cylinder, and the volume of the cylinder is 0.050 m^3. The weight on top of the cylinder has a mass of 10.0 kg. The temperature of the gas is 19.0 °C.



(a) Calculate the pressure of the gas. [3]

(b) (SMTP) Determine how many molecules there are in the gas. [3]

(c) The temperature is increased to 152 °C. Calculate the new volume of the gas. [3]

3. Four main types of processes involve gases: *isothermal*, *isobaric*, *isochoric* and *adiabatic*. Are these processes quick or slow?

(a) Isothermal: .....

.....

(b) Isobaric: .....

.....

(c) Isochoric: .....

.....

(d) Adiabatic: .....

.....

4. Using the kinetic particle theory, explain the following:

(a) The pressure of an ideal gas increases when the volume is decreased at constant temperature,

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..... [3]

(b) The pressure of an ideal gas increases when the temperature is increased at constant volume,

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..... [3]

(c) The volume of an ideal gas increases when the temperature is increased at constant pressure.

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..... [3]

5. A Bunsen burner is used to heat a beaker full of water.

(a) Explain how energy is transferred through the bottom of the beaker.

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..... [2]

(b) Explain how energy is transferred through the water.

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..... [2]

c Several centimetres to one side of the Bunsen burner, a student's hand starts to feel hot. Explain the process by which energy is transferred from the burner to the student's hand.

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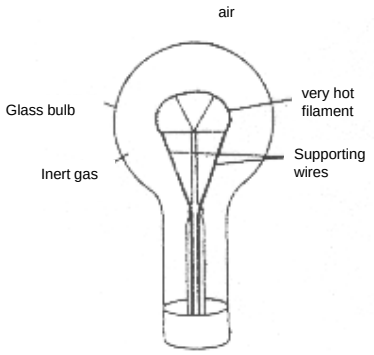
..... [2]

6. The figure on the right shows a filament lamp standing upright in the air.



a On the figure, draw arrows to represent radiation from the filament. [1]

b State two places where thermal *conduction* takes place.

c Describe briefly the two convection currents which are set up.

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..... [2]

7. A saucepan with a thick copper base contains water and is placed on a flat electric hot plate.

a State and describe the process by which energy is

(i) transferred from the hot plate to the water;

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..... [2]

(ii) spread through the water.

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..... [2]

b Suggest **three** reasons why the water would reach boiling point more rapidly with a lid on the pan.

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..... [3]

c The sides of saucepans are often polished. How does this reduce heat loss?

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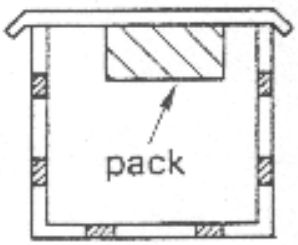
..... [1]

8. As shown in the diagram, a pack of frozen liquid is placed in a holder under the box's lid. The box is then used to keep food cold.



a Suggest why the frozen pack is placed at the top of the box rather than at the bottom.

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..... [2]

b Why does the food keep cold longer if the walls

(i) are made of rigid plastic rather than of metal,

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..... [1]

(ii) have a layer of lagging on the outside?

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..... [1]

9. Explain why a mercury-in-glass laboratory thermometer has

a a narrow capillary bore,

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..... [2]

b a bulb made of very thin glass?

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..... [2]

10.

The diagram (not to scale) shows two mercury thermometers, A and B, identical in every respect except that the bulb of A is much larger than that of B.

State, giving a reason for your answer in each case, which thermometer

a will cover the larger range of temperature,

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..... [2]

b will indicate more quickly a small temperature rise.

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..... [2]

11. A mercury-in-glass thermometer has a scale starting at $-10\ °C$ and finishing at $110\ °C$. The length of the scale is 240 mm.

a What is the range of the thermometer?

..... [1]

b Determine the sensitivity of the thermometer in $mm\ K^{-1}$ (or $mm\ °C^{-1}$).

..... [1]

A second thermometer has a bulb with twice the volume of the thermometer in part (a). Its length and bore are just the same as those of the thermometer in part (a).

State, justifying your answer in each case,

c the range of the second thermometer,

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..... [2]

d the sensitivity of the second thermometer.

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..... [2]

12. When the hot end of a thermocouple thermometer is placed in a bath of liquid at 0 °C , its e.m.f. reading is found to be 22 mV. When the liquid bath is heated to 100 °C , the e.m.f. reading becomes 50 mV. After that, the bath is cooled until the e.m.f. reading is 42 mV. The cold end of the thermocouple remains in melting ice throughout.

a What is the temperature of the bath as measured using the thermocouple when the e.m.f. reading is 42 mV?

[2]

b The reading taken at the same time on a mercury-in-glass thermometer placed in the bath is 40 °C .

(i) Suggest a reason for the difference between this reading and the value calculated in part (a).

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..... [2]

(ii) Will there be any value(s) where the thermometers give a similar reading? State the reason.

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..... [2]

c Name the physical property which varies with temperature in
(i) a mercury-in-glass thermometer;
(ii) a thermocouple thermometer.

(i) ..... (ii) .....

d State

(i) two advantages of a mercury-in-glass thermometer;
(ii) two advantages of a thermocouple thermometer.

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..... [4]

13. If deep-sea divers rise to the surface too quickly, nitrogen bubbles in their blood can expand and prove fatal. This phenomenon is known as **the *bends***. If a scuba diver rises quickly from a depth of 25 m in Lake Michigan (which is fresh water and the pressure at that depth is 3.46×10^5 Pa),

(a) what will be the volume of an N_2 bubble that occupied 1.0 mm^3 in his blood at the lower depth?

[3]

(b) Does it seem that the difference is large enough to be a problem?

(*Assume that the pressure difference is due only to the changing water pressure and not to any temperature difference. This assumption is reasonable since we are warm-blooded creatures.*)

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..... [2]

14. The gas inside a balloon will always have a pressure nearly equal to atmospheric pressure since that is the pressure applied to the outside of the balloon. You fill a balloon with helium (a nearly ideal gas) to a volume of 0.600 L at a temperature of 20.0 ^{o}C. What is the volume of the balloon if you cool it to the boiling point of liquid nitrogen (77.3 K)?

[3]

15. (SMTP) The giant hornet *Vespa mandarinia japonica* preys on Japanese bees. However, of one of the hornets attempts to invade a beehive, several hundred of the bees quickly form a compact ball around the hornet to stop it. They don't sting, bite, crush or suffocate it. Instead, they overheat it by quickly raising their body temperatures from the normal 35 °C to 47 °C or 48 °C, which is lethal to the hornet but not the bees.

Assume the following: 500 bees form a ball of radius $R = 2.0$ cm for a time $t = 20$ min. The primary loss of energy by the ball is by thermal radiation. The ball's surface has emissivity $e = 0.80$, and the ball has a uniform temperature. On average, how much *additional* energy must each bee produce during the 20 min to maintain 47 °C?

16. (SMTP) Water standing in the open at 32.0 °C evaporates because of the escape of some of the surface molecules. The heat of vaporization (2255 J/g) is approximately equal to εn, where ε is the average energy of the escaping molecules and n is the number of molecules per gram.

(a) Determine the value of ε.

(b) What is the ratio of ε to the average kinetic energy of H_2O molecules, assuming the latter is related to temperature in the same way for gases?

17. (SMTP) This is a hard question on ideal gas.

Container A in the figure shown holds an ideal gas at a pressure of 5.0×10^5 Pa and a temperature of 300 K. It is connected by a thin tube (and a closed valve) to container B, with four times the volume of A. Container B holds the same ideal gas at a pressure of 1.0×10^5 Pa and a temperature of 400 K. The valve is opened to allow the pressures to equalize, but the temperature of each container is maintained. What then is the pressure?