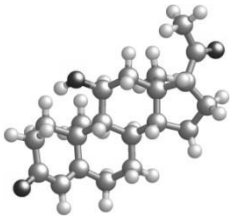


Chem!stry

Name: …… **( )**

Class: ……

Date: …… **/** …… **/** ……

Kinetic Particle Theory – Enrichment and Discussion Questions

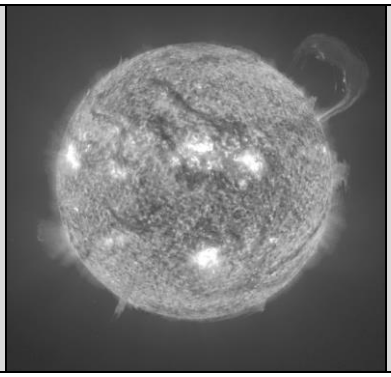
Question One:

Did you know…?
A flight on Concorde from London to New York takes three-and-a-half hours. Taking into account the five-hour time difference between the two cities, this means that passengers actually arrive in New York before they departed from London!

Concorde was the World's only supersonic passenger airliner. When flying over the Atlantic ocean at a height of 17.7 km and a speed of 2170 km / h (twice the speed of sound), Concorde's external airframe reached a temperature of 130°C at the nosecone and 90°C at the tail. This caused Concorde to expand in length from 62.10 m to 62.22 m.

- Why did Concorde's external airframe heat-up during supersonic flight over the Atlantic ocean?
- Why did this increase in Concorde's temperature cause it to expand?

Question Two:



Did you know…?

- The highest temperature ever recorded on Earth was 57.8°C at El Azizia, Libya, on 13th September 1922.
- The lowest temperature ever recorded on Earth was –89.2°C at Vostok, Antarctica, on 21st July 1983. It was so cold that boiling water poured from a kettle froze before it reached the ground!
- The temperature of the Sun (photographed left) varies from 5500°C on its surface to 15 000 000°C at its core.

- Use your knowledge of kinetic particle theory to predict whether or not there is a minimum temperature to which matter can be cooled and whether or not there is a maximum temperature to which matter can be heated. Explain your reasoning.

Question Three:

Did you know…?
The prize for the chemical with the most unpleasant smell on Earth would probably be awarded to ethyl mercaptan (formula: CH_3CH_2SH) which has a smell described as a combination of garlic, onions, rotting cabbage, burnt toast and sewage gas!

- Describe the process by which an attractive perfume worn by a woman on one side of a room can be smelt by somebody standing on the opposite side of the same room.
- What factors affect how fast the person is able to smell the woman's perfume?

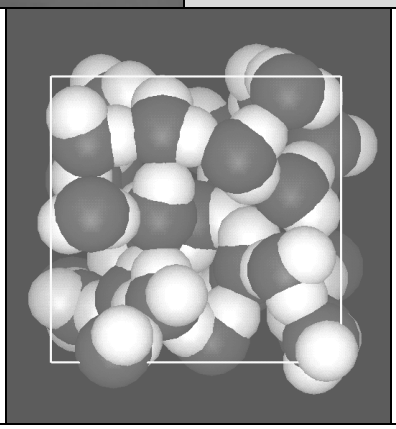
Question Four:

Did you know…?
The kinetic theory of matter states that the particles in a solid are more closely packed together than the particles in a liquid. As a consequence of this, a solid will have a greater density than the corresponding liquid.

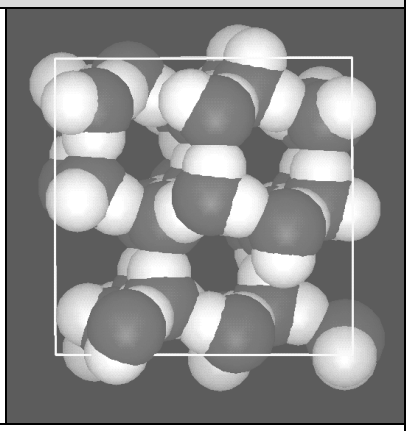
Except in the case of water!

The density of solid ice is 0.931 g / cm^3. This compares with a density of 1.00 g / cm^3 for liquid water. Solid ice is less dense than liquid water because the water molecules (formula: H_2O) are actually packed more closely together in the liquid compared to the solid (see the two diagrams below for reference). Water has its maximum density at 4°C.

This diagram shows the arrangement of water molecules in ***liquid water***.



This diagram shows the arrangement of water molecules in ***solid ice***. Note the spaces that now exist between the water molecules.

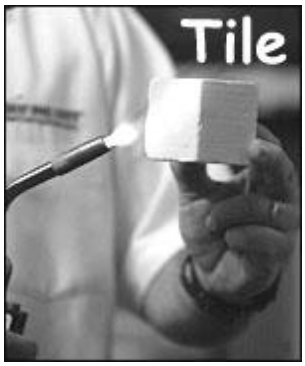


- What would the world be like if solid ice was more dense than liquid water?
- How and why would this have affected the evolution of life on Earth?
- For which other chemicals is the solid phase less dense than the liquid phase?

Question Five:

Did you know…?

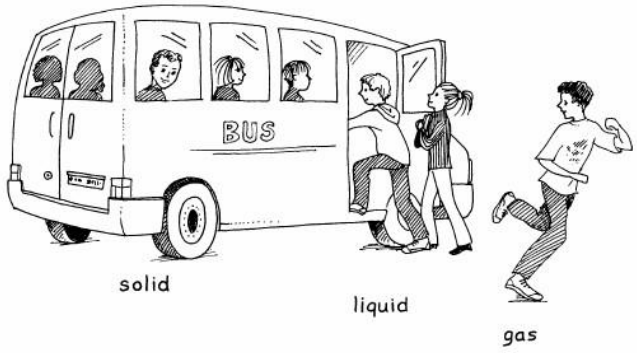
- It takes only eight minutes for the Space Shuttle to accelerate to a speed of 17000 miles per hour (27359 km / h)!
- Each of the Space Shuttle's solid rocket boosters burns five tons (4536 kg) of fuel per second!
- During take-off, the Space Shuttle's two solid rocket boosters develop more thrust than 35 Boeing 747 jumbo jets!



The exterior of the Space Shuttle is covered with 32000 ceramic tiles. These tiles must withstand temperatures that vary from –120°C (while the Shuttle is in Earth's orbit) to 1650°C (while the Shuttle re-enters the Earth's atmosphere).

- What are the main properties that the Space Shuttle's ceramic tiles should have? Look at the photographs above to give you some clues.

Question Six:



Did you know…?

The 18th century German Physicist Daniel Gabriel Fahrenheit (1686-1736) is believed to be the first person to make a reliable mercury thermometer. On his thermometer Fahrenheit took 0ºF to be what he believed to be the coldest temperature that could exist, a mixture of ice and salt, and 96ºF to be the only other temperature that he believed to be constant, the temperature of the human body.

0°C = 32°F
100°C = 212°F

The diagram above illustrates an everyday model of the three states of matter, solids, liquids and gases. Models help scientists to visualize and understand complex or abstract ideas.

- In what way does the diagram above illustrate a model of a solid a liquid and a gas? How accurate is this model? What are its limitations?
- Come up with your own model to describe the arrangement of particles in solids, liquids and gases.
- Think of a suitable model to describe the process of diffusion.

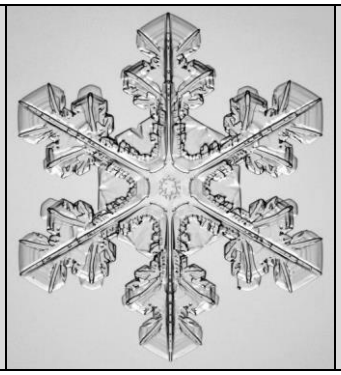
Question Seven:

Did you know…?
At a pressure of 1 atmosphere, pure water boils at 100°C. At a higher pressure, pure water has a higher boiling point and at a lower pressure, pure water has a lower boiling point. The pressure inside a pressure cooker is approximately 2 atmospheres. Consequently, water inside a pressure cooker boils at approximately 120°C (this is why food cooks more quickly inside a pressure cooker). The pressure at the top of Mount Everest is only ⅓ atmosphere. Consequently, water at the top of Mount Everest boils at approximately 70°C.

- What would the world around us be like if solids could be compressed? What would be different and what would be the same? How would these differences benefit our lives, and in what ways would they prove to be a nuisance?

- What are the main medical problems that climbers experience at high altitude? In what way is the high altitude responsible for these medical conditions? www.high-altitude-medicine.com

Question Eight:



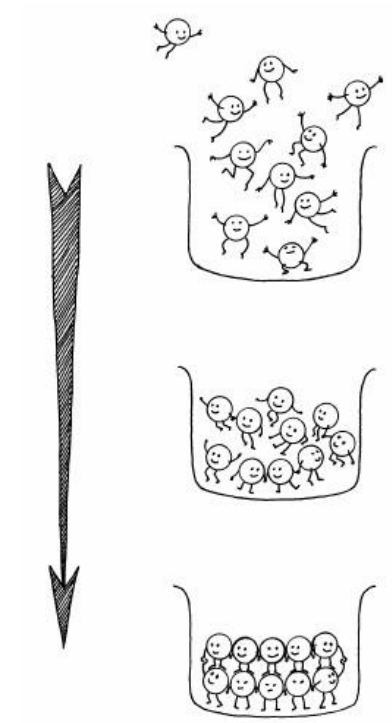
Did you know…?
- A pure substance has a sharp melting point.

- An impure substance melts over a range of temperatures. In addition, and impurity will *reduce* the *melting point* of a solid, but *increase* the *boiling point* of a liquid.

- The largest snowflake is reported to have fallen at Fort Keogh, Montana, USA, on 28th January 1887. The snowflake was 38 cm (15 inches) wide and 20 cm (8 inches) thick!

- During the winter in countries such as Japan, Germany and Canada the temperature can drop to –3°C. Explain why the roads and pavements in these countries are covered with salt (sodium chloride) when meteorologists forecast heavy snow.

Question Nine:



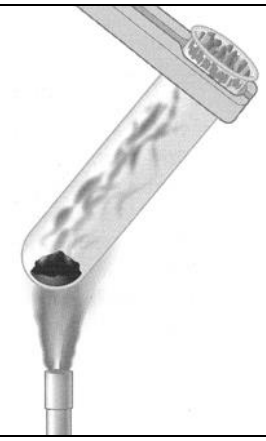
Did you know…?
Here are the melting points and boiling points of some common elements and compounds:

Element	Melting Point / °C	Boiling Point / °C
Hydrogen (H_2)	–259	–252.5
Carbon (graphite – C)	3727	4827
Nitrogen (N_2)	–210	–195.6
Oxygen (O_2)	–218.6	–182.8
Sodium (Na)	98	890
Chlorine (Cl_2)	–101	–35
Titanium (Ti)	1677	3257
Iron (Fe)	1537	2927
Copper (Cu)	1083	2595
Bromine (Br_2)	–7	59
Silver (Ag)	961	2207
Tungsten (W)	3407	5927
Gold (Au)	1063	2967
Mercury (Hg)	–39	357
Lead (Pb)	327	1744
Methane (CH_4)	–182.3	–161.3
Ethanol (CH_3CH_2OH)	–117	79
Ammonia (NH_3)	–77	–33
Sulphur dioxide (SO_2)	–73	–10
Sodium chloride (NaCl)	801	1467

- Describe what happens to the particles in a solid as it is heated to its melting point, and then as the resulting liquid is heated to its boiling point.
- Imagine that you and your classmates are the particles in a gas. Describe what happens to you as you condense to a liquid and eventually cool to form a solid.

Question Ten:

The sublimation of iodine.
The dark grey crystals of iodine change directly into a purple vapor when warmed over a blue Bunsen burner flame. As the iodine vapor rises up the test tube and cools, it changes back into a solid near the mouth of the test tube.

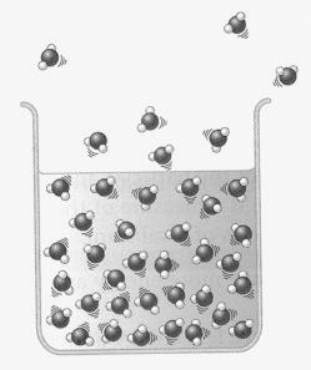


Did you know…?

- The kinetic theory of matter states that all matter is composed of particles that are in a constant state of motion.
- Matter is defined as anything that has mass and volume.

- Use your knowledge of chemical bonding and the kinetic theory of matter to explain why some solids, such as iodine, sublime instead of melting when they are heated in the laboratory.

Question Eleven:



Did you know…?

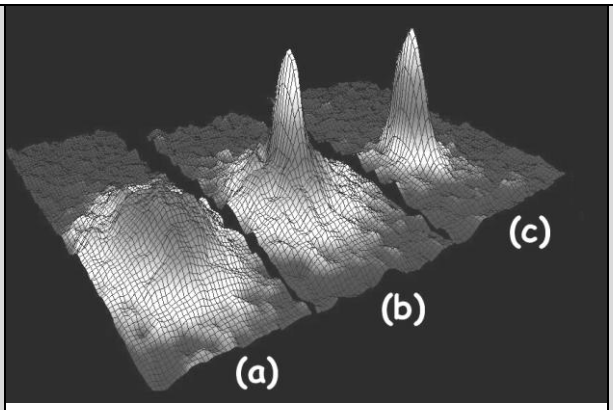
- The place with the lowest average annual rainfall on Earth is Quillagua, in the Atacama Desert, Chile. For the period between 1964 and 2001, the average annual rainfall was measured at just 0.5 mm.
- The place with the highest annual rainfall ever recorded on Earth is Cherrapunji, Meghalaya, India. For the period between 1st August 1860 and 31st July 1861, the total rainfall was measured at 26461 mm (1041 inches).

After heavy rain, large puddles of water can be seen on the ground. Over a period of time, these puddles of water will slowly ***evaporate*** forming water vapor in the air.

If a beaker of water is allowed to stand on a tripod over a blue Bunsen burner flame, the water will eventually start to ***boil*** and change into a gas (steam).

- What is the difference between ***evaporate*** and ***boil***? What happens to the molecules of water in a puddle as the water evaporates? What happens to the molecules of water in a beaker of boiling water?

Question Twelve:



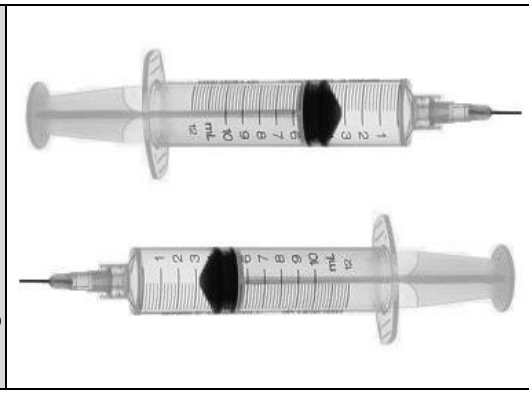
The diagram above shows (**a**) the cloud of rubidium atoms just before formation of the Bose-Einstein Condensate (**b**) just after formation of the condensate (**c**) nearly pure condensate.

Did you know…?

In addition to solids, liquids, gases and plasmas, there is a fifth state of matter known as a ***Bose-Einstein Condensate***. Its existence was predicted in 1924 by Satyendra Nath Bose and Albert Einstein, although science had to wait until 5th June 1995 for it to be created when Carl Wieman and Eric Cornell at the University of Colorado successfully cooled 2000 atoms of rubidium close to absolute zero (–273.15°C). At this temperature all of the rubidium atoms combined together and behaved as a single ***super atom***. Carl Wieman, Eric Cornell and Wolfgang Ketterle won the 2001 Nobel Prize in Physics for their work on Bose-Einstein Condensates.

- What are the objects / substances / materials around you that are difficult to classify as either solids, liquids or gases?

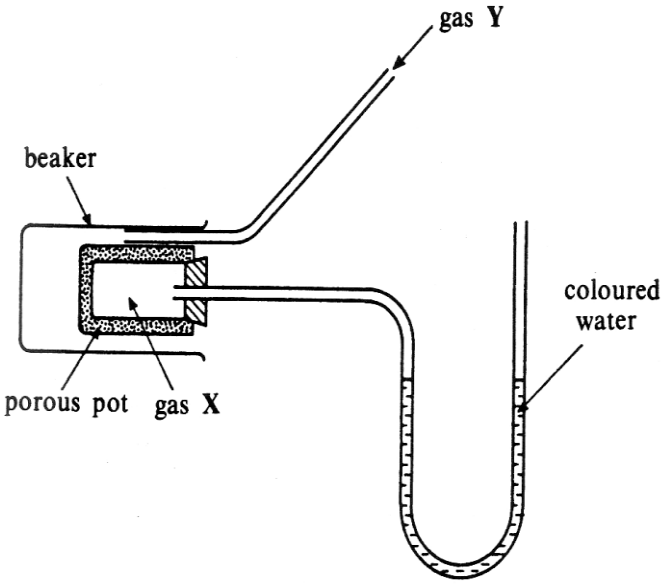
Question Thirteen:



Did you know…?
Before injecting a drug into a patient's arm, a doctor will wipe the patient's arm with an alcohol (ethanol) pad. This is to kill any micro–organisms living on the patient's skin which would otherwise cause an infection when the patient's skin is punctured by the needle.
A solution of ethanol (80 cm^3 ethanol and 20 cm^3 water) is an effective disinfectant, killing most bacteria, fungi and viruses. It kills the micro–organisms by denaturing their proteins and dissolving their lipids.

- Ethanol is a volatile liquid with a boiling point of 79°C. Explain why a patient feels a cold sensation on their arm after it has been wiped with an alcohol pad, just before they have an injection.
- Explain why a person, who is making a cup of tea or coffee, feels extreme pain if their hand or arm accidentally comes into contact with the steam coming from the kettle of boiling water.

Question Fourteen:



Did you know…?
The velocity of a particle in the gas phase is related to its mass according to the following equation:

$$u = \sqrt{\frac{3RT}{M}}$$

Where:
u = velocity, m / s
R = gas constant, 8.31 J / mol / K
T = temperature, K
M = molecular mass, kg / mol

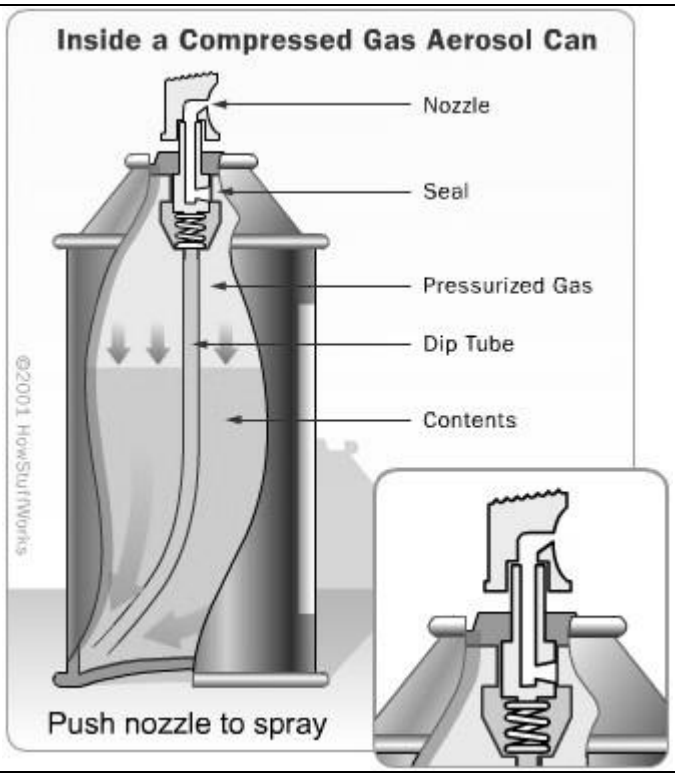
Velocity of some gases at room temperature:
He = 1360 m / s
N_2 = 515 m / s

- Look at the diagram above and consider the following pairs of gases:

[A] **X** = CO_2 **Y** = C_2H_6
[B] **X** = CH_4 **Y** = NO_2
[C] **X** = N_2 **Y** = C_2H_4
[D] **X** = O_2 **Y** = Ar

- Which pair(s) of gases will cause the level of the coloured water in the left-hand-side of the U tube to ***rise***?
- Which pair(s) of gases will cause the level of the coloured water in the left-hand-side of the U tube to ***fall***?
- Which pair(s) of gases will cause ***no change*** in the level of the coloured water?

Question Fifteen:



Did you know…?

Aerosol cans once contained chlorofluorocarbons (CFCs) as propellants. CFCs have since been found to damage the ozone (formula – O_3) layer:

$CCl_2F_2 + UV\ light \rightarrow \cdot CClF_2 + \cdot Cl$

$\cdot Cl + O_3 \rightarrow \cdot ClO + O_2$

Note: the dot represents a single, unpaired electron in the valence shell of the atom or molecule. Atoms and molecules that contain a single, unpaired electron are described as ***radicals***.

The 1995 Nobel Prize in Chemistry was awarded to Mario Molina, Sherwood Rowland and Paul Crutzen for identifying the chemical reactions that destroy the ozone layer.

Aerosol cans contain a propellant as well as the main contents that the consumer wants to use. The propellant may be a pressurized gas or a liquefied gas that is mixed with the main contents.

- Use you knowledge of kinetic particle theory to describe what changes take place inside an aerosol can when the nozzle is pressed down.

- Why is the bottom of the aerosol can curved?

- Why do aerosol cans have signs on them saying
Warning: do not puncture
and
Warning: do not destroy by incineration?

- Which chemicals have replaced CFCs as the propellants in aerosols? What are the disadvantages of using these chemicals as propellants?

www.howstuffworks.com
www.nobel.se

Question Sixteen:

Did you know…?

The world's tallest building is the *Burj Khalifa* (also known as the *Burj Dubai* or *Dubai Tower*) located in the city of Dubai in the United Arab Emirates. The building was officially opened on the 4th January 2010 and stands 828 m tall.

The building cost US$ 1.5 billion to construct. In addition to its foundations, the actual tower required 330 000 m^3 of concrete, 31 400 000 kg of steel and took 22 000 000 man-hours to complete.

http://www.burjkhalifa.ae/

- The temperature at the top of the *Burj Khalifa* is 10°C *lower* than the temperature at the bottom of the tower.

- What possible reasons explain why temperature *decreases* as altitude *increases*?

- Imagine that you are an engineer working on the design and construction of the *Burj Khalifa*. What technical challenges would you expect to encounter due to the temperature difference between the top and bottom of the tower? From a scientific perspective, suggest how these challenges might be overcome.

Question Seventeen:

Did you know…?

The longest concert of all time was written in 1987 by avant-garde pioneer John Cage. The concert titled *As Slow As Possible* started in 2001 and is scheduled to finish in 2640.

John Cage is also famous for his 1952 opus titled *4' 33"*, an entirely silent piece written in three movements.

- From a scientific point-of-view, what is the significance of 4' 33" of complete silence?