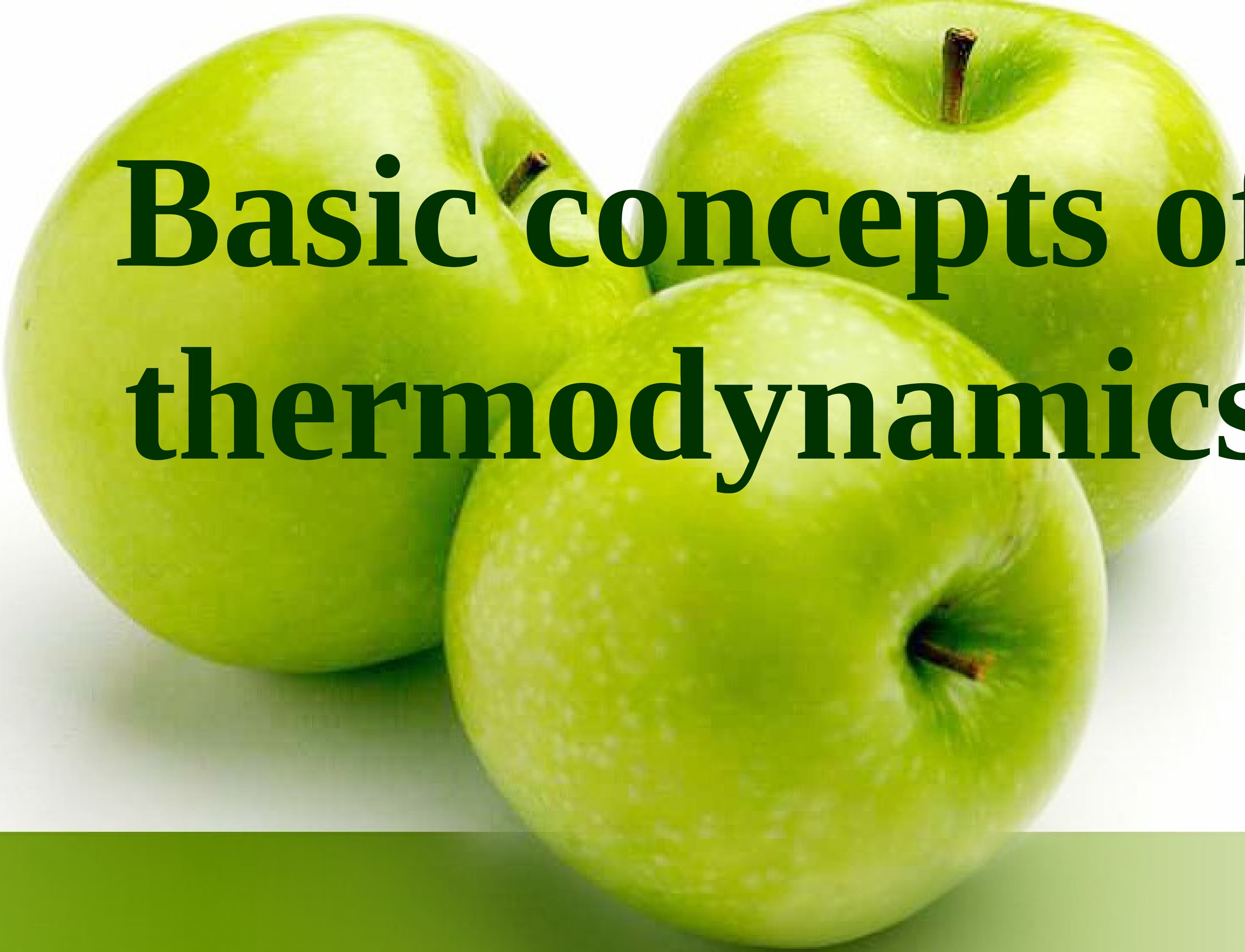
Basic concepts of thermodynamics



IB PHYSICS (II)

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Main objectives of lecture

<u>Essential idea</u>: **Thermal physics deftly demonstrates the links between the macroscopic measurements essential to many scientific models with the microscopic properties that underlie these models.**

Specific objectives of lecture

Understandings:

- Molecular theory of solids, liquids and gases
- Temperature and absolute temperature
- Internal energy
- Specific heat capacity
- Phase change
- Specific latent heat

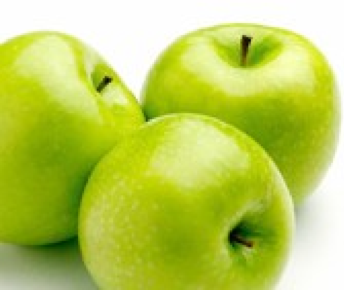
Applications and skills:

- Describing temperature change in terms of internal energy
- Using Kelvin and Celsius temperature scales and converting between them
- Applying the calorimetric techniques of specific heat capacity or specific latent heat experimentally

General objective

Checking and application of Isaac Newton's law of cooling

$$\frac{dT}{dt} = -k\Delta T$$



Nature of science

International-mindedness:

- The topic of thermal physics is a good example of the use of international systems of measurement that allow scientists to collaborate effectively

Theory of knowledge:

- Observation through sense perception plays a key role in making measurements. Does sense perception play different roles in different areas of knowledge?

Utilization:

- Pressure gauges, barometers and manometers are a good way to present aspects of this sub-topic
- Higher level students, especially those studying option B, can be shown links to thermodynamics (see *Physics* topic *9* and option sub-topic *B.4*)
- Particulate nature of matter (see *Chemistry* sub-topic *1.3*) and measuring energy changes (see *Chemistry* sub-topic *5.1*)
- Water (see *Biology* sub-topic *2.2*)

Thermal concepts

Guidance:

- Internal energy is taken to be the total intermolecular potential energy + the total random kinetic energy of the molecules
- Phase change graphs may have axes of temperature versus time or temperature versus energy
- The effects of cooling should be understood qualitatively but cooling correction calculations are not required

Aims:

- **Aim 3:** an understanding of thermal concepts is a fundamental aspect of many areas of science
- **Aim 6:** experiments could include (but are not limited to): transfer of energy due to temperature difference; calorimetric investigations; energy involved in phase changes

Thermal concepts - exercises

A temperature *is an objective comparative measure of hot or cold. It is measured by a thermometer, which may work through the bulk behavior of a thermometric material, detection of thermal radiation, or particle kinetic energy. Several scales and units exist for measuring temperature, the most common being Celsius (denoted °C; formerly called centigrade), Fahrenheit (denoted °F), and, especially in science, Kelvin (denoted K).The coldest theoretical temperature is absolute zero, at which the thermal motion of atoms and molecules reaches its minimum - classically, this would be a state of motionlessness, but quantum uncertainty dictates that the particles still possess a finite zero-point energy. In addition to this, a real system or object can never be brought to a temperature of absolute zero by thermodynamic means. Absolute zero is denoted as 0 K on the Kelvin scale, −273.15 °C on the Celsius scale, and −459.67 °F on the Fahrenheit scale.*

Answer the questions:

1. A solid piece of tungsten melts into liquid without a change in temperature. Which of the following is correct for the molecules in the liquid phase compared with the molecules in the solid phase?

	Kinetic energy	Potential energy
A.	same	greater
B.	same	same
C.	greater	greater
D.	greater	same

2. Two objects are in thermal contact with each other. Which of the following will determine the direction of the transfer of thermal energy between the bodies?

A. The mass of each body

B. The area of contact between the bodies

C. The specific heat capacity of each body

D. The temperature of each body

3. For two objects to be in thermal equilibrium they must

A. be in contact with each other.

B. radiate equal amounts of power.

C. have the same thermal capacity.

D. be at the same temperature.

4. An ice cube and an iceberg are both at a temperature of 0 °C. Which of the following is a correct comparison of the average random kinetic energy and the total kinetic energy of the molecules of the ice cube and the iceberg?

	Average random kinetic energy	Total kinetic energy
A.	same	same
B.	same	different
C.	different	same
D.	different	different

Laboratory exercises
PART 1

Suggest the experiment which confirm the validity of the Newton`s temperature decay law (law of cooling).

Laboratory exercises PART 1

```
T=function('T',x)
var('k,g')
k=0.25
g=298
rownanie=T.diff(1)==(-k)*(T-g)
show(rownanie)
var('x0,T0')
x0=0
T0=373
a=desolve(rownanie, T, ivar=x, ics=[x0,T0])
show(a)
plot(a, xmin=0,xmax=20, ymin=g, ymax=T0, color='red',
thickness=2, fill=True, fillcolor="gold", marker="o",
markerfacecolor="blue", plot_points=1, legend_label="T(t)",
axes_labels=["t","T(t)"])
```

Laboratory exercises PART 1