Gases

(1)

The diagram shows the shock-absorber of an automobile:

Shock absorber

Reference : Petit Larousse illustré
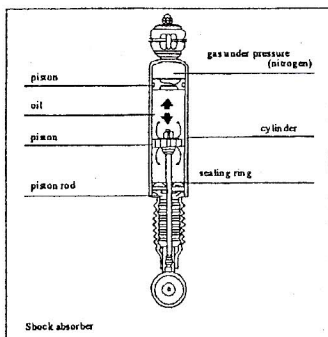
Shock-absorber : A device for absorbing the energy of sudden impulses or shocks in machinery or structures

From the list below, select the properties of gases that justify their use in a shock-absorber.

| 1.Malleability | 2. Hardness | 3. Compressibility | 4. Ductibility | 5. Indefinite shape | 6. Viscosity | 7.Conductivity |

A)   2 and 7   B) 5, 6 and 7   C) 3 and 5   D) 1, 2 and 4

(2)

Two tanks filled with gas are under the same conditions of temperature and pressure. One is filled with hydrogen H_2 and the other with nitrogen N_2.

According to Avogadro's law, which of the following statements is true?

A)   Nitrogen molecules are more numerous than hydrogen molecules.

B)   Nitrogen molecules are as numerous as hydrogen molecules.

C)   The two tanks contain equal masses of gases.

D)   Nitrogen molecules are less numerous than hydrogen molecules.

(3)

. A glass flask contains helium under pressure. The needle of a syringe is inserted through the stopper; you observe that the piston rises for a certain time and then becomes stationary.

BEFORE   AFTER
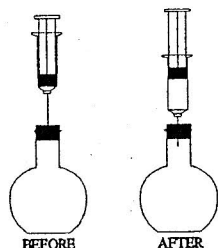
Which of the following graphs best represents the observed phenomenon?

A)   B)   C)   D)
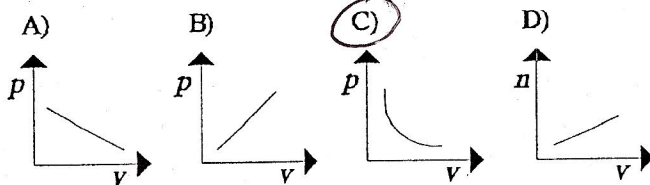
(4)

Volume, pressure, and temperature are the three variables that determine the state of a certain mass of gas.

Boyle's Law describes the relationship between the pressure and the volume of a fixed mass of gas at constant temperature.

What is the relationship?

A)   The pressure is directly proportional to the volume.

B)   The pressure is directly proportional to the square of the volume.

C)   The ratio of the pressure over the volume is constant.

D)   The product of the pressure and the volume is constant.

(5)

... Gas is stored in the first 1 000-litre reservoir, at a pressure of 612 kPa, and a temperature of 20 C. The tap in the pipe that connects the first reservoir, containing the gas, with the second reservoir, initially empty, is opened.
At equilibrium, the temperature of the gas remains at 20°C and the pressure in the two reservoirs is 204 kPa.
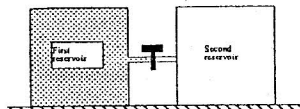
What is the volume of the second reservoir?

A)   500 litres   B) 1 000 litres   C) 1 500 liters   D) 2 000 liters

6 A fixed amount of helium is contained in a rigid container at a pressure of 400 kPa and temperature of 20°C. What will be the pressure of the gas in this container if the temperature changes to 40°C?

A)   200 kPa   B) 374 kPa   C) 427 kPa   D)   800 kPa

7a) Identify the type(s) of motion that predominate in each of the three states of matter. (each type of motion can be used more than once)

State	Motion
• solid	• translation
• liquid	• vibration
• gas	• rotation

Solid - vib
liq - vib, rot.
gas - vib, rot, trans

b) A container is filled with nitrogen (N_2) and its mass determined. It is then emptied and filled with an unknown gas under the same conditions of temperature and pressure and its mass is determined. The following results are obtained:

Mass of nitrogen   : 0.07 g
Mass of unknown gas   : 0.16 g

What is the molar mass of the unknown gas?

$$0.07g \; N_2 \times \frac{1 \, mol}{28.02 g} = 2.5 \times 10^{-3} \, mol \; N_2$$

$$\text{molar mass:} \quad mm = \frac{m}{n} = \frac{0.16g}{2.5 \times 10^{-3} mol} = \boxed{64 g/mol}$$

8 A cylinder of oxygen (O_2), is left in a hot car. The cylinder has a volume of 1.0 L and contains 17 L of oxygen measured at S.T.P.

If the cylinder can withstand a pressure of 2 100 kPa, what is the highest temperature to which the cylinder can be safely exposed?

Show all your work.

$$\boxed{T = 332.5 K}$$

9 The valve of an oxygen (O_2) cylinder is defective and the cylinder is leaking. The volume of the cylinder is 34 dm^3. On Monday morning the technician had recorded a pressure of 452 kPa and a temperature of 23°C. Four days later the pressure was 402 kPa and the temperature was 18°C.

If the cylinder had contained chlorine (Cl_2) rather than oxygen, under the same conditions, would the cylinder have emptied more rapidly, less rapidly or at the same rate as the oxygen?

Justify your answer.

$$\boxed{19.2 g \; O_2 \; lost}$$

→ *cylinder would have emptied more rapidly with O_2 because it has a lower molar mass ∴ diffuses faster.*

10 A sample of gas at a temperature of 35 °C is in a cylinder with a volume of 10.0 L. The pressure is 125.8 kPa.

a) How many moles of gas are there?

$$\boxed{n = 0.49 mol}$$

b) If the gas is moved into a cylinder with a volume of 8.4 L and a pressure of 174.2 kPa, what is the temperature in °C?

$$\boxed{T_2 = 86.26 °C}$$

11 A gas has a volume of 31.2 dm^3 at a temperature of 28 °C and a pressure of 82.6 kPa. Assuming that it is an ideal gas, how many moles of gas are there? How many molecules of gas are there?

$$\boxed{n = 1.03 \, mol}$$

$$\boxed{1.03 \, mol \times 6.02 \times 10^{23} \frac{molecules}{1 mol} = 6.02 \times 10^{23}}$$

12 What volume will 15.00 g of carbon monoxides occupy at STP, assuming it behaves like an ideal gas?

$$\boxed{V = 11.99 L}$$

13 What is the mass of 0.420 L of NO_2 measured at 101.3 kPa and 27°C? $\boxed{m = 0.785 g}$

14 The density of gas is 1 43 g/L at STP. Determine the density of this gas at 17 °C and 93.3 kPa pressure.

Step 1: $\boxed{mm = 32.03 g/mol}$ Step 2: $\boxed{d = 1.24 \frac{g}{L}}$

15 An experiment was conducted to identify an unknown gas. You proceeded as follows:

The mass of an empty 140 mL syringe was determined. The unknown gas was then placed in the syringe and a second reading for the mass was taken. The following data were obtained:

$T = 25°C$ $P = 101.3 \, kPa$

mass of empty syringe : 76.52 g
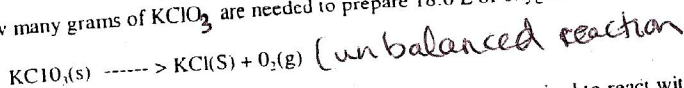mass of syringe + gas x : 76.70 g
($R = 8.31$ kPa • L/mol • K)

$$\boxed{31.5\cancel{4} \; 43 \; g/mol} \; O_2$$

Which of the following is the unknown gas?

He , Ne , CO_2 , O_2 , N_2 , H_2 , CH_4

Show all your work.

16 How many grams of $KClO_3$ are needed to prepare 18.0 L of oxygen at 22 °C and 101.3 kPa?

$KClO_3(s) \; ------> KCl(S) + O_2(g)$ (unbalanced reaction)

$$\boxed{60.77 g}$$ ← *correct number (good job Miss Rebel!)*

17 What volume of oxygen measured at 27 °C and 152.0 kPa is required to react with 2.50L of ammonia at 127 °C and 101.3 kPa?

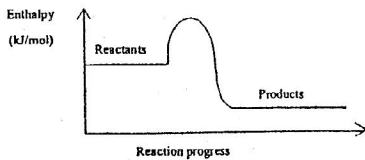$4 NH_3(g) + 5 O_2(g) \; ------> 4 NO(g) + 6 H_2O(l)$

$$\boxed{V = 1.56 L}$$

Thermodynamics

① The following diagram shows the change in enthalpy of the substance involved in a chemical reaction.

Enthalpy (kJ/mol) — Reactants ... Products — Reaction progress

Given this diagram, which of the following statements is TRUE?
A) This is an endothermic reaction.
B) The enthalpy of the products is greater than that of the reactants.
C) The ΔH for this reaction is negative.
D) This is a spontaneous reaction.

② Which of the following equations represents an endothermic chemical change?
A) $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$ + Energy
B) $H_2O_{(l)}$ + Energy $\rightarrow$ $H_2O_{(g)}$ ← Physical (vaporization)
C) $NaOH_{(s)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$ + Energy
D) $2NH_{3(g)}$ + Energy $\rightarrow$ $N_{2(g)} + 3 H_{2(g)}$

A reaction is represented by the following equation:

$$A + B \rightarrow C + x \text{ kJ}$$
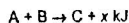
③ What is TRUE about this reaction?
A) The enthalpy of the product is greater than the enthalpy of the reactants.
B) The enthalpy of the product may be greater than or equal to the enthalpy of the reactants.
C) The enthalpy of the product is less than the enthalpy of the reactants.
D) The enthalpy of the product may be less than or equal to the enthalpy of the reactants.
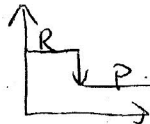
④ The following statements concern the enthalpy of substances:
1. When a chemical bond forms, the enthalpy decreases.
2. When a chemical bond is broken, the enthalpy decreases.
3. When a chemical bond is broken, the enthalpy increases.
4. When a chemical bond forms, the enthalpy increases.

Which of the statements are true?
A) 1 and 3   B) 1 and 4   C) 2 and 3   D) 2 and 4

⑤ The following represents an enthalpy diagram:

Enthalpy (kJ) — X ... Y ... Z — Progress of reaction
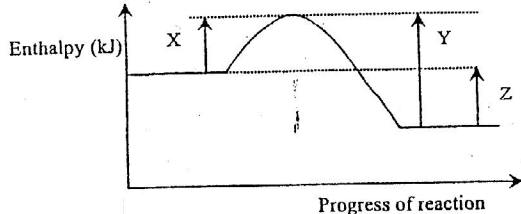
Which of the following statements is correct?
A) Y represents ΔH of the reverse reaction, which is exothermic.
B) X represents ΔH of the forward reaction, which is exothermic.
C) Z represents ΔH of the reverse reaction, which is endothermic.
D) X represents ΔH of the forward reaction, which is endothermic.

⑥ Robert pours a hot (58°C) cup of tea (250 mL) into a styrofoam cup. He adds 40 mL of cold water to the tea to cool it so that he can drink it. After adding the cold water, the final temperature of the tea is 50°C.

What was the initial temperature of the cold water Robert added to his cup of tea?
A) 0.0°C
B) 4.0°C
C) 42.0°C
D) 48.7°C

(handwritten) tea. cold water. $-Q = Q$ assume tea has same specific heat as water.
$\left(-250g\left(\frac{4.19J}{g°C}\right)(8°C)\right) = 40g\left(\frac{4.19J}{g°C}\right)(50°C-x)$
$8380J = 167.6\frac{J}{°C}(50°C-x)$
$50 = 50-x$ $-x = 50°C-50°C = 0°C$

⑦ When 2.00 g of potassium hydroxide, KOH, is dissolved in 100 mL of water, the temperature of the solution rises from 20.0°C to 26.5°C.

What is the molar heat of solution of KOH?
A) -1.36 kJ/mol   B) -2.72 kJ/mol   C) -54.5 kJ/mol   D) -76.4 kJ/mol

⑧ Which of the following phenomena are considered to be exothermic?
1. Alcohol evaporates very rapidly from a warm surface. $l \rightarrow g$ endo
2. Gasoline burns in internal combustion engines.
3. When sodium hydroxide is dissolved in water, the temperature of the water rises.
4. In winter, ice crystals often form on window panes. $g \rightarrow s$ exo
5. Magnesium metal, after ignition, gives off an intense white light. exo
6. When ammonium chloride is dissolved in water, the temperature of the water drops. endo

A) 1, 2, 5 and 6   B) 1, 3, 4 and 5   C) 2, 3, 4 and 5   D) 2, 3, 4 and 6

⑨ A 4.00×10^2 g piece of iron at 22.0°C is heated in a bomb calorimeter until the temperature is 250.0°C. If the iron absorbs 41.04 kJ of heat, what is the specific heat capacity of the iron?
A) 4.5×10^{-4} J/(g•°C)
B) 4.5×10^{-1} J/(g•°C)
C) 4.5 J/(g•°C)
D) 4.5×10^{1} J/(g•°C)

(10) You mix 100 mL of a 0.5 mol/L solution of NaOH$_{(aq)}$ with 100 mL of a 0.5 mol/L solution of HCl$_{(aq)}$. Before mixing, the two solutions were at the same temperature. After mixing, you observe a temperature increase of 4.5°C.

What is the molar heat (ΔH) of neutralization of the HCl$_{(aq)}$? SHOW ALL YOUR WORK.

$$-75.42 \text{ KJ/mol}$$

(11) A lab technician took 50 mL of a 1.0 mol/L solution of hydrochloric acid (HCl) to neutralize 50 mL of a 1.0 mol/L solution of sodium hydroxide (NaOH). The initial temperature of the two solutions was 22.5°C. The final mixing temperature was 29.2°C.

What was the molar heat of neutralization (ΔH) of the sodium hydroxide?

(Assume the specific heat of solution is equivalent to the specific heat of water.)

Show all your work.

$$-56.2 \text{ KJ/mol}$$

(12) In an experiment, 1.40 grams of potassium hydroxide pellets, KOH$_{(s)}$, are placed in a calorimeter containing 1.50×10^2 mL of water. The temperature of the water increases from 25.0°C to 28.0°C.

What is the molar heat of solution of KOH?

$$-75.6 \text{ KJ/mol}$$

(13) In order to determine how much heat is released during the combustion of candle wax, C$_{25}$H$_{52}$, a burning candle is used to heat some water in a metal can that serves as a calorimeter.

The following data is obtained:

Volume of water heated	355.0 mL
Initial mass of candle	136.0 g
Final mass of candle	112.0 g
Initial temperature of the water	15.4°C
Final temperature of the water	23.0°C

Calculate the molar heat of combustion of the candle wax.

$$\Delta H = -166.24 \text{ KJ/mol}$$

(14) Methyl alcohol (CH$_3$OH$_{(l)}$) is generally used as a fuel to heat the oil in fondue sets.

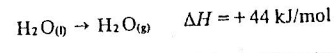What mass of methyl alcohol is needed to heat 1.10 kg of fondue oil from 22.0°C to 98.0°C?

N.B.: Specific heat capacity of fondue oil is : 8.9 kJ/kg•K

Equation for the combustion of methyl alcohol is:

$$m = 37.18 \text{ g}$$

CH$_3$OH$_{(l)}$ + 3/2 O$_{2(g)}$ → CO$_{2(g)}$ + 2 H$_2$O$_{(g)}$ + 639 kJ
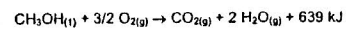
(15) Following the evaporation of water, a student derives the following thermochemical equation.

$$H_2O_{(l)} \rightarrow H_2O_{(g)} \qquad \Delta H = +44 \text{ kJ/mol}$$

During his research, he finds the enthalpy for the products (H$_2$O$_{(g)}$) to be 924 kJ. Based on this information, calculate the enthalpy for the reactants (H$_2$O$_{(l)}$).

$$880 \text{ KJ}$$

(16) Methanol, CH$_3$OH, and ethanol, C$_2$H$_5$OH, can be used as fuel for a burner. The following diagrams show the energy released during the combustion of one mole of each substance.
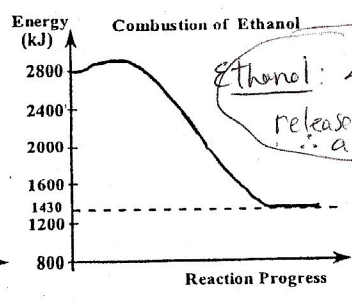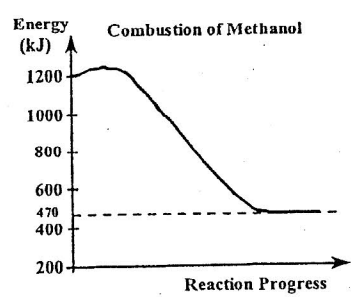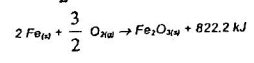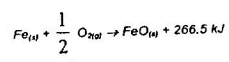
Methanol: $\Delta H = -730$ KJ/mol

Ethanol: $\Delta H = -1370$ KJ/mol
releases more for 1 mol
∴ also more for 1g

Which of the two combustion reactions illustrated above releases the most energy when 1 g of substance is burned? Show all your work.

(17) Iron is a resistant material that is widely used. Unfortunately, this metal tends to oxidize quickly in air. The heat of formation of its oxide, Fe$_2$O$_{3(s)}$, is difficult to measure by means of a simple experiment.

The following two thermochemical equations represent the reaction of iron and oxygen gas:

$$Fe_{(s)} + \frac{1}{2} O_{2(g)} \rightarrow FeO_{(s)} + 266.5 \text{ kJ}$$

$$2 Fe_{(s)} + \frac{3}{2} O_{2(g)} \rightarrow Fe_2O_{3(s)} + 822.2 \text{ kJ}$$

Given these equations, you are to find the amount of heat involved in the formation of 1 mol of Fe$_2$O$_{3(s)}$ according to the following reaction :

$$2FeO_{(s)} + \frac{1}{2} O_{2(g)} \rightarrow \qquad Fe_2O_{3(s)}$$
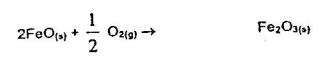
How much heat is involved in the formation of 1 mol of Fe$_2$O$_{3(s)}$?
A) 1088.7 kJ released B) 555.7 kJ released C) 289.2 kJ released D) 289.2 kJ absorbed

(20) Given the following equations, calculate the heat of combustion for ammonia, NH$_3$.

NH$_3$ + 5/4 O$_2$ → NO + 3/2 H$_2$O $\qquad \Delta H = -293.3$ kJ

NO + ½ O$_2$ → NO$_2$ $\qquad \Delta H = -58.8$ kJ

NO$_2$ + 1/3 H$_2$O → 2/3 HNO$_3$ + 1/3 NO $\qquad \Delta H = -44.6$ kJ

12 NH$_3$ + 21 O$_2$ → 8 HNO$_3$ + 4 NO + 14 H$_2$O $\qquad \Delta H = -4760.4$ kJ

(19) Given these equations: 6 C(s) + 3 H$_2$(g) → C$_6$H$_6$(l) $\qquad \Delta H = -51.0$ kJ
C(s) + O$_2$(g) → CO$_2$(g) $\qquad \Delta H = -394.1$ kJ
H$_2$(g) + ½ O$_2$(g) → H$_2$O(g) $\qquad \Delta H = -242.2$ kJ

Determine the molar heat of combustion for benzene as per the reaction below:

C$_6$H$_6$(l) + 15/2 O$_2$(g) → 6 CO$_2$(g) + 3 H$_2$O(g) $\qquad \Delta H = -3040.2$ KJ

(18) A contractor wants to know whether propane (C$_3$H$_8$) or methane (CH$_4$) is the better fuel.

The combustion equations for both substances are the following:

C$_3$H$_8$(g) + 5 O$_{2(g)}$	→	3 CO$_{2(g)}$ + 4 H$_2$O$_{(g)}$
CH$_{4(g)}$ + 2 O$_{2(g)}$	→	CO$_{2(g)}$ + 2 H$_2$O$_{(g)}$

Given the following information:

H$_{2(g)}$ + 1/2 O$_{2(g)}$	→	H$_2$O$_{(g)}$ + 242 kJ
C$_{(s)}$ + O$_{2(g)}$	→	CO$_{2(g)}$ + 393 kJ
C$_{(s)}$ + 2 H$_{2(g)}$	→	CH$_{4(g)}$ + 75 kJ
3 C$_{(s)}$ + 4 H$_{2(g)}$	→	C$_3$H$_{8(g)}$ + 104 kJ

Which fuel would you suggest he use and for which reason? Show all your work.

C$_3$H$_8$ $\Delta H = -2043$ KJ/mol   CH$_4$ $\Delta H = -962$ KJ/mol

-802

∴ Better, releases more heat