PAPER 2
ESSAY
[100 marks]

Answer **four** *questions in all: Question* **1** *in Section* **A** *and* **three** *questions from Section* **B**.
All *questions carry equal marks.*
Credit will be given for clarity of expression and orderly presentation of material.

SECTION A

Answer **all** *the questions in this section.*

1. (*a*) Give two characteristics of compounds in a homologous series. [2 marks]

(*b*) Distinguish between a *strong acid* and a *weak acid* according to the Bronsted-Lowry theory. [2 marks]

(*c*) Give three industrial uses of electrolysis. [3 marks]

(*d*) Draw structures for two structural isomers of the compound C_5H_{12}. [4 marks]

(*e*) Give the IUPAC name for each of the following molecules:

(i) $CH_3(CH_2)_3CH(C_2H_5)CH_3$;

(ii) $CH_3CH(CH_3)(CH_2)_2C\equiv CH$;

(iii) $CH_2{=}CHCH_2OH$. [3 marks]

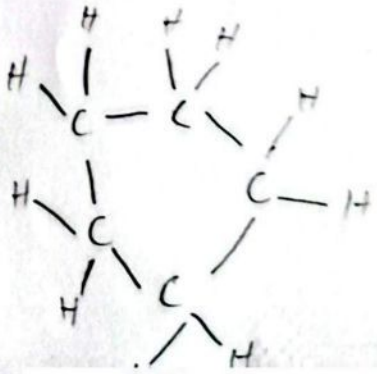
(*f*) State two factors that determine the selective discharge of ions in an electrolytic cell. [2 marks]

(*g*) Differentiate between a *galvanic cell* and an *electrolytic cell*. [2 marks]

(*h*) What is the effect of an electric field on cathode rays? [2 marks]

(*i*) Give a reason why some atomic mass values are not whole numbers. [2 marks]

(*j*) List three factors that enhance ionic bond formation. [3 marks]



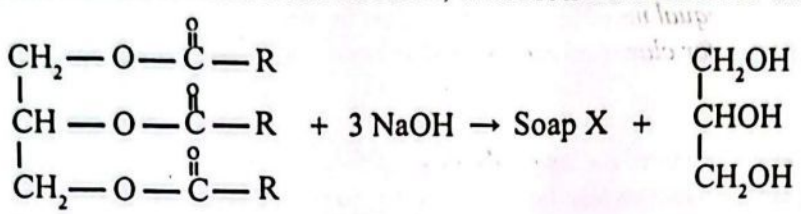
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SECTION B

Answer **three** *questions* **only** *from this section.*

2. (*a*) Soap can be prepared from the reaction between oil and concentrated sodium hydroxide. The equation for the reaction is shown below, where R is a carbon chain with 15 carbon atoms.



(i) Name the reaction above.

(ii) Draw the structural formula of the soap X formed.

(iii) On the diagram drawn in (ii), label the hydrophobic and hydrophilic parts of the soap. **[5 marks]**

(*b*) A solution of methanoic acid has a concentration of 0.100 mol dm^{-3}, calculate the concentration of

(i) the non-ionised acid;

(ii) **each** of the ions at equilibrium.

[$K_a = 1.7 \times 10^{-4}$] **[10 marks]**

(*c*) A student carried out an experiment to determine the enthalpy of neutralization for the reaction between 50 cm^3 of 2.0 mol dm^{-3} hydrochloric acid and 50 cm^3 of 2.0 mol dm^{-3} sodium hydroxide solution.

The following data was obtained:

Initial temperature of hydrochloric acid and sodium hydroxide solution = 31.10 °C

Highest temperature reached for the mixture = 42.20 °C

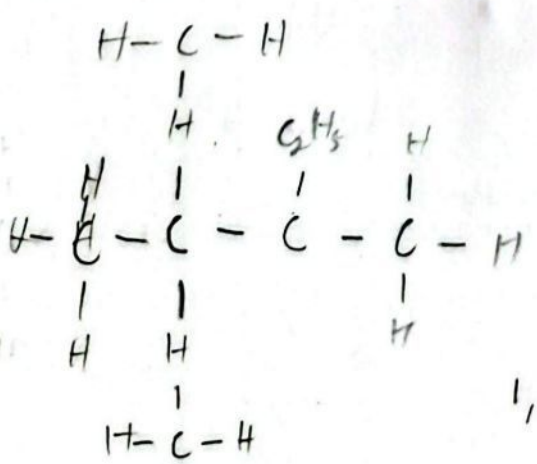
(i) Calculate the enthalpy of neutralization for the reaction.

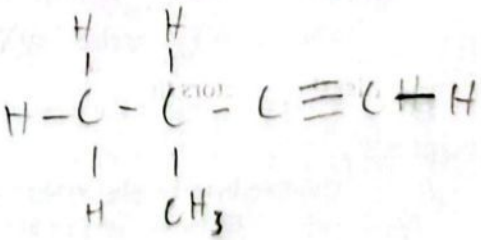
(ii) If the experiment is repeated using tetraoxosulphate(VI) acid in place of hydrochloric acid and all other conditions are maintained, predict the enthalpy change.

(iii) Explain the answer given in (ii).

[S.H.C of water = 4200 $JKg^{-1}K^{-1}$] **[8 marks]**

(*d*) State the *law of multiple proportions*. **[2 marks]**





1,2,2-triethyle-3-methyl butane

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Presence of hydrogen atoms
Presence of carbon atoms
in form a straight line

3. (a) (i) State **three** general properties common to the compounds:
CH_3CH_2OH, $CH_3CH(CH_3)CH_2OH$ and CH_3OH

(ii) (α) Arrange the compounds CH_3CH_2COOH, HCOOH and CH_3COOH in order of **increasing** acid strength.

(β) Explain the order of acid strength given in (α).

[8 marks]

(b) (i) Define the term *ionization energy*.

(ii) List **four** factors that determine the ionization energy values.

(iii) Explain **briefly** the trend of variation of ionization energy values across the periods.

[11 marks]

(c) How many molecules of carbon(IV) oxide would be produced when 0.01 mol of Na_2CO_3 reacts with $HCl_{(aq)}$ completely?
[$N_A = 6.02 \times 10^{23}$ mol^{-1}]

$Na_2CO_3 + HCl \longrightarrow NaCl_2 + CO_2 + H_2$ [6 marks]

4. (a) The first four ionization energies (in kJ mol^{-1}) of four elements A, B, C and D are given in the table ~~below~~:

ELEMENT	1ST	2ND	3RD	4TH
A	1012	1907	2914	4964
B	496	4563	6910	9545
C	787	1577	3231	4355
D	738	1451	7733	10,542

M
N·M
N·M
N·M

This is because the amount of energy required increases along the table

Based on the ionization energy values given;

(i) Classify **each** of the elements as metal or non-metal.

(ii) Explain the classifications made in (i).

[10 marks]

(b) (i) Name a **suitable** indicator that could be used for **each** of the following titrations:

(α) $CH_3COOH_{(aq)}$ against $KOH_{(aq)}$

(β) $CH_3COOH_{(aq)}$ against $NH_{3(aq)}$ Phenolphtaline

(γ) $H_2SO_{4(aq)}$ against $NH_{3(aq)}$ methyl orange

(δ) $HCl_{(aq)}$ against $NaOH_{(aq)}$ litmus paper

(ii) Give a reason for the answer given in (i)(β)

[5 marks]

(c) (i) Explain **briefly** why tertiary alkanols resist oxidation.

(ii) (α) Draw the structural formula of the tertiary alkanol with the **least** number of carbon atoms.

(β) Name the structure drawn in (α).

[5 marks]

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(*d*) (i) (α) Name a reagent that could react with an alkanol to produce a combustible gas.

(β) Name the gas produced in (α).

(ii) Which of the following compounds would be **more** soluble in water?

$(CH_3)_3COH$ or $CH_3(CH_2)_2CH_2OH$

(iii) Give a reason for the answer given in (ii). **[5 marks]**

5. (*a*) Calculate the pH of the resulting mixture when 20 cm^3 of 0.10 mol dm^{-3} NaOH is added to 25 cm^3 of 0.10 mol dm^{-3} CH_3COOH.

[Ka = 1.7×10^{-5} at 25 °C]

[10 marks]

(*b*) (i) State Gay-Lussac's law.

(ii) A gas cylinder contains oxygen at a pressure of 20 °C.

If the temperature increases to 40 °C, what would be the new pressure, assuming the volume remains constant?

[5 marks]

(*c*) Explain **briefly** how the solubility of a sparingly soluble salt, AgCl would be affected when some NaCl is added to its saturated solution.

[5 marks]

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(*d*) A redox reaction occurs between iron(II) ions, Fe^{2+} and tetraoxomanganate(VII) ions, MnO_4^- in acidified aqueous solution.

Write the:

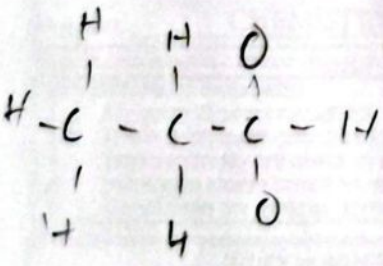
(i) oxidation half cell equation for the reaction;

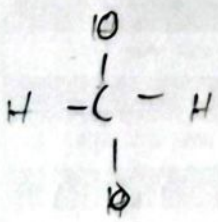
(ii) reduction half cell equation for the reaction;

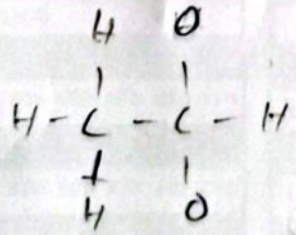
(iii) overall balanced equation.

[5 marks]

END OF ESSAY TEST







$HCOOH > CH_3CH_2COOH > CH_3COOH$

Answer **all** *the questions.*

Each question is followed by **four** *options lettered* **A** *to* **D**. *Find the* **correct** *option for* **each** *question and shade in* **pencil** *on your answer sheet, the answer space which bears the same letter as the option you have chosen. Give only* **one** *answer to* **each** *question. An example is given below.*

Which of the following elements reacts with water?
A. Carbon
B. Sodium
C. Sulphur
D. Iodine

The correct answer is **Sodium** *which is lettered* **B** *and therefore answer space* **B** *would be shaded.*

⊏A⊐ **⊏B⊐** ⊏C⊐ ⊏D⊐

Think carefully before you shade the spaces; erase completely **any** *answer you wish to change.*

Do **all** *rough work in this question paper.*

Now answer the following questions.

1. In a hydrogen fuel cell experiment, 6.00 mol of hydrogen gas reacted with 4.00 mol of oxygen gas. Given the balanced chemical equation; $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$
How many moles of water will be formed from the complete reaction of these gases?
A. 2.00 mol
B. 4.00 mol
C. 6.00 mol
D. 8.00 mol

2. Why is soap classified as a base?
A. It donates protons during reactions.
B. It has a slippery feel.
C. It reacts with acids to neutralize them.
D. It releases hydroxide ions in water.

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3. Why is a temperature of ~ 450 °C used in the Contact process despite the reaction being exothermic?
A. To maximize sulphur(VI) oxide yield at equilibrium
B. To reduce energy costs for heating during the process
C. To prevent the decomposition of the vanadium(V) oxide catalyst
D. To ensure a reasonable reaction rate while maintaining some yield

4. All the following substances are toxic **except**
A. benzene.
B. cyanide.
C. dynamite.
D. pesticide.

5. A sample of ammonium chloride is dissolved in 100 g of water, causing the temperature to drop from 25 °C to 15 °C. What does this temperature change indicate about the nature of the dissolution process?
A. ΔH is positive and the process is endothermic.
B. ΔH is positive and the process is exothermic.
C. ΔH is negative and the process is endothermic.
D. ΔH is negative and the process is exothermic.

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6. Which of the following properties is common to both strong acids and strong bases?
   A. High electrical conductivity
   B. Partial dissociation in water
   C. pH close to 7 in solution
   D. Slow reaction with metals

7. A gaseous mixture contains oxygen and nitrogen. If the partial pressure of oxygen is 300 mmHg and the total pressure of the gaseous mixture is 760 mmHg, what is the partial pressure of nitrogen?
   A. 300 mmHg
   B. 460 mmHg
   C. 760 mmHg
   D. 1060 mmHg

8. How does temperature generally affect the solubility of solids in liquids?
   A. Solubility decreases with increasing temperature.
   B. Solubility remains constant with temperature change.
   C. Solubility increases with increasing temperature.
   D. Solubility is unaffected by increase in temperature.

9. A gas is compressed to half of its original volume at constant temperature. What would happen to its pressure?
   A. It decreases by half.
   B. It remains the same.
   C. It doubles.
   D. It quadruples.

10. Consider the equilibrium reaction:
    $2HI_{(g)} \rightleftharpoons H_{2(g)} + I_{2(g)}$
    If pressure is doubled, what would be the effect on the equilibrium position?
    A. It shifts to the right.
    B. It shifts to the left.
    C. No shift occurs.
    D. It shifts in both directions.

11. In a radioactive decay of an isotope of Bismuth to Polonium, a particle $^{0}_{-1}Y$ is emitted. What particle is $^{0}_{-1}Y$?
    A. Electron
    B. Ion
    C. Neutron
    D. Proton

12. Which conditions are optimized in the Haber process to balance equilibrium and reaction rates?
    A. Atmospheric pressure, low temperature, no catalyst
    B. High pressure, low temperature, catalyst
    C. High pressure, moderate temperature, catalyst
    D. Low pressure, high temperature, catalyst

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13. The following statements are all postulates of the Dalton's atomic theory **except** ....
   A. All elements are made up of small indivisible particles called atoms
   B. Atoms cannot be created nor destroyed
   C. Atoms of different elements are identical
   D. Atoms of different elements combine in simple whole number ratios

14. A calorimeter was used to compare two fuels. Fuel *X* released 25.0 kJ while fuel *Y* released 30.0 kJ. However, fuel *Y* burned more completely and produced less soot.
Which of the following conclusions is **most** valid?
   A. Fuel *Y* has a higher calorific value.
   B. Fuel *X* is a better fuel because it releases more energy.
   C. Fuel *Y* is more efficient due to complete combustion.
   D. Fuel *X* is cleaner and more sustainable.

15. Given the following data:

$N_{2(g)} + O_{2(g)} \rightarrow 2NO_{(g)}$ $\quad \Delta H = +180 \text{ kJ mol}^{-1}$

$2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$ $\quad \Delta H = -114 \text{ kJ mol}^{-1}$

What is the enthalpy change for the reaction:

$N_{2(g)} + 2O_{2(g)} \rightarrow 2NO_{2(g)}$?

   A. +66 kJ mol^{-1}
   B. +294 kJ mol^{-1}
   C. -294 kJ mol^{-1}
   D. -66 kJ mol^{-1}

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16. Which of the following concepts defines a base as a substance that accepts protons?
   A. Arrhenius
   B. Bronsted-Lowry
   C. Lewis
   D. Bronsted

17. Which of the following arrangements **correctly** ranks intermolecular forces from **weakest** to **strongest**?
   A. Hydrogen bonding < dipole-dipole < London dispersion
   B. Hydrogen bonding < London dispersion < dipole-dipole
   C. Dipole-dipole < London dispersion < hydrogen bonding
   D. London dispersion < dipole-dipole < hydrogen bonding

18. The balanced chemical equation for the formation of ammonia is $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$.
Based on the equation, how many molecules of hydrogen gas are needed to completely react with 750 molecules of nitrogen gas?
   A. 250 molecules
   B. 750 molecules
   C. 1500 molecules
   D. 2250 molecules

19. Why does carbon tetrachloride lack dipole-dipole interactions despite having polar C-Cl bonds?
   A. Chlorine atoms are non-polar.
   B. Electrons are evenly distributed in the molecule.
   C. The molecule has no lone pairs on chlorine.
   D. The tetrahedral symmetry cancels bond dipoles.

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20. In the reaction $CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$, what is the conjugate base of CH_3COOH?
A. H_2O
B. CH_3COO^-
C. H_3O^+
D. OH^-

21. An unknown element, Z, has the following abbreviated electron configuration: [Kr] $5s^2\ 4d^{10}\ 5p^2$. Which of the following statements about Z is **correct**?
A. It is a transition element in group 12.
B. It is a metalloid in group 14.
C. It is a noble gas in group 18.
D. It is a non-metal in group 16.

22. In biological systems, it is essential that the pH stays constant in order for any process to work properly. The constant pH of blood is about
A. 6.8
B. 7.0
C. 7.2
D. 7.4

23. Which of the following rows has the **correct** information?

	Molecule	Shape	Total number of pairs of electrons in the valence shell of the central atom
A.	CO_2	Linear	Two
B.	BCl_3	Trigonal planar	Four
C.	H_2O	Bent / V-shape	Two
D.	NH_3	Tetrahedral	Four

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24. The angular momentum quantum number, 1, describes the shape of the s-orbital within an energy level. Which of the following arrangements best shows the correct values of '1' for the s,p,d,f sub-orbital respectively?
A. 0,1,2,3
B. 0,2,1,2
C. 1,2,3,0
D. 3,2,1,0

25. What does the hazard symbol below indicate?



A. Biological hazard
B. Combustible substance
C. Explosive substance
D. Radioactive substance

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26. A student recorded the volume of gas evolved during a reaction every 30 seconds. The table below shows the results:

Time/s	Vol./cm³
0	0
30	18
60	32
90	42
120	48
150	50

At what time was the rate of reaction fastest?

A. 0-30 s
B. 30-60 s
C. 60-90 s
D. 120-150 s

27. Which of the following household items is classified as an acid?

A. Baking soda
B. Lemon juice
C. Milk of magnesia
D. Powdered soap

28. How does atomic radius change as atomic number increases across a period? It

A. decreases.
B. increases.
C. is constant.
D. is irregular.

29. The electron configuration of $_{13}Al^{3+}$ is .....

A. $1s^2\ 2s^2\ 2p_x^2\ 2p_y^2\ 2p_z^2$
B. $1s^2\ 2s^2\ 2p_y^2\ 2p_x^2\ 2p_z^2$
C. $1s^2\ 2s^2\ 2p_z^2\ 2p_y^2\ 2p_x^2$
D. $1s^2\ 2p^2\ 2s^2\ 2p_x^2\ 2p_y^2$

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30. An alkyl alkanoate is shown: $CH_3COOC(CH_3)_3$
Which two compounds reacted to form this alkanoate?

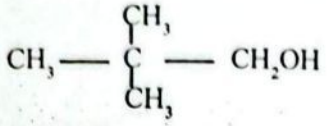
A. 2-methylpropan-1-ol and ethanoic acid
B. 2-methylpropan-2-ol and ethanoic acid
C. 2-methylpropan-2-ol and propanoic acid
D. Propan-1-ol and 2-methylpropanoic acid

31. The combustion of methane is exothermic. What happens to the energy of the system?

A. The system gains heat energy.
B. The system stores more chemical energy.
C. The system loses heat energy.
D. The system becomes hotter than the surrounding.

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32. What is the empirical formula of the compound:



A. $C_5H_{12}O$
B. C_5H_6O
C. $C_5H_{11}OH$
D. C_6H_6O

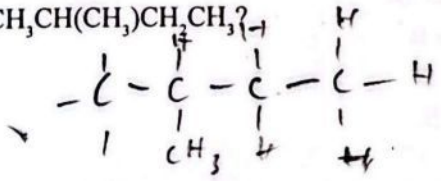
33. Which of the following features is a characteristic of organic compounds?
A. High melting and boiling points
B. Ionic bonding between atoms
C. Presence of carbon-hydrogen bonds
D. Solubility in polar solvents like water

34. Which of the following factors can shift the position of a chemical equilibrium?
A. Catalyst, light intensity, colour change
B. Concentration of reactants, temperature, pressure
C. Stirring rate, density, solvent polarity
D. Surface area of solids, catalyst, volume

35. Before adding $AgNO_{3(aq)}$ in the Lássaigne test for halogens, the solution is acidified with HNO_3. What is the primary purpose of this step?
A. To accelerate the formation of silver halide precipitates
B. To dissolve any unreacted organic material
C. To neutralize excess sodium metal
D. To remove interfering ions like sulphide or cyanide

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37. What is the IUPAC name for $CH_3CH(CH_3)CH_2CH_3$?
A. 2-methylbutane
B. 3-methylbutane
C. Isopentane
D. Pentane



38. If pressure is increased in the Haber process, how does it affect the equilibrium position?
A. Shifts towards reactants
B. Shifts towards products
C. No effect on equilibrium
D. Attainment of equilibrium

39. The compound CH_3CH_2OH could be classified as an
A. alkanoic acid.
B. alkane.
C. alkanol.
D. alkanoate.

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40. A 0.1 mol dm^{-3} solution of HCl and a 0.1 mol dm^{-3} solution of KOH are prepared. What are their respective pH values?
A. pH = 0.1, pH = 0.1
B. pH = 1, pH = 13
C. pH = 7, pH = 7
D. pH = 13, pH = 1

41. Two hydrocarbons have the formula C_aH_m and C_yH_n. *a*, *m*, *y* and *n* represent different whole numbers. $\frac{a}{m} = \frac{y}{n}$
Which of the following options is **correct** when comparing the two hydrocarbons based on their empirical formula, molecular formula and relative molecular mass respectively?
A. Different, same, different
B. Different, same, same
C. Same, different, different
D. Same, different, same

42. Which of the following statements is a characteristic of particles in a solid?
A. Particles are widely spaced and free to move
B. Particles are closely packed and have fixed positions
C. Particles are randomly arranged and can flow
D. Particles are widely spaced and have fixed positions

43. A container holds a mixture of ice and water at 0°C. What will happen to the temperature of the mixture if heat is added? The temperature would
A. increase immediately until all the ice melts.
B. remain constant until all the ice melts.
C. decrease immediately until all the ice melts.
D. fluctuate until all the ice melts.

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44. According to Graham's law of diffusion, if the molecular weight of gas A is four times that of gas B, how will their rates of diffusion compare? Gas A will diffuse
A. two times faster than gas B.
B. half times as fast as gas B.
C. $\frac{1}{4}$ times as fast as gas B.
D. 4 times faster than gas B.

45. A container holds a mixture of oxygen, nitrogen and carbon(IV) oxide at a total pressure of 10 atm. If the partial pressures of oxygen and nitrogen are 2 atm and 4 atm respectively, what percentage of the total pressure is due to carbon(IV) oxide?
A. 20%
B. 30%
C. 40%
D. 60%

46. Which of the following properties is characteristic of a catalyst?
A. It alters the rate of a chemical reaction.
B. It changes chemically at the end of the reaction.
C. It is completely used up in a chemical reaction.
D. Its mass is changed at the end of the reaction.

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47. According to Hess's law, what can be done to calculate the enthalpy of a complex reaction?
A. Measure the enthalpy change directly.
B. Ignore the enthalpy changes of individual steps.
C. Calculate the enthalpy change from the enthalpy changes of individual steps.
D. Assume the enthalpy change is always zero.

48. A gaseous mixture contains helium and argon. If the rate of effusion of helium is twice that of argon, what can be inferred about their molecular weights?
A. Helium has a higher molecular weight than argon
B. Helium has a lower molecular weight than argon
C. Helium and argon have the same molecular weight
D. The molecular weight of helium and argon are incomparable

49. Which of the following statements is **true** about bond breaking and bond forming?
A. Bond breaking releases energy, bond forming requires energy
B. Bond breaking requires energy, bond forming releases energy
C. Bond breaking and bond forming both require energy
D. Bond breaking and bond forming both release energy

50. In the scientific method, which step involves carefully watching and recording information about a phenomenon the scientist desires to investigate?
A. Analyze data collected
B. Conduct experiments
C. Formulate questions
D. Make observations

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