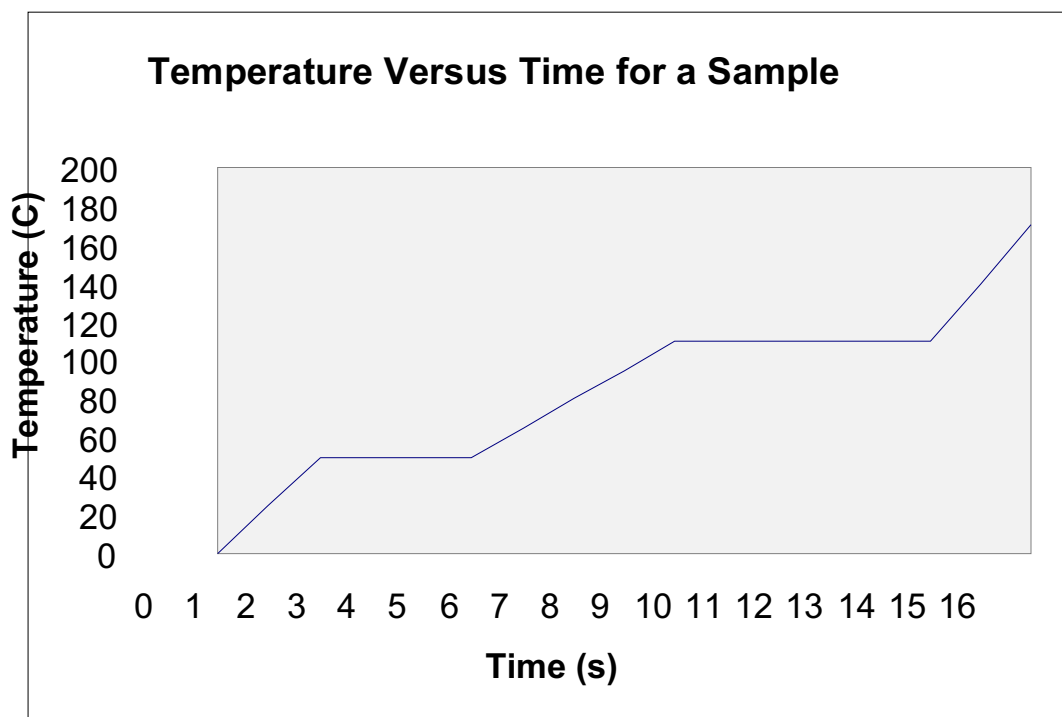


**PART A: EXTENDED ANSWERS (50 marks – 50% of assessment mark)**

All work must be shown to obtain full marks. Attention must be paid to units.

**I: Physical Properties of Matter (7 marks)**

1. Starting as a solid, a sample of a substance is heated at a constant rate. The graph below shows the changes in temperature of this sample.



- a) What is the melting point of this sample? (1 mark)
- b) What is the boiling point of this sample? (1 mark)
- c) What state is the sample in from 5 – 9 seconds? (1 mark)
- d) Explain why the temperature does not change from 9 – 14 seconds. (1 mark)

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2. Using your Vapour Pressure vs. Temperature for  $\text{CHCl}_3$ ,  $\text{CCl}_4$  and  $\text{H}_2\text{O}$  chart provided in your data booklet, answer the following questions.

a) Under normal atmospheric conditions, which substance(s) would be boiling at  $80^\circ\text{C}$ ? (1 mark)

b) State the atmospheric conditions necessary to enable water to boil at  $60^\circ\text{C}$ . (1 mark)

c) In terms of average kinetic energy, differentiate between water at  $20^\circ\text{C}$  and water at  $100^\circ\text{C}$ . Assume normal atmospheric conditions for both samples. (1 mark)

## II: Gases and the Atmosphere (7 marks)

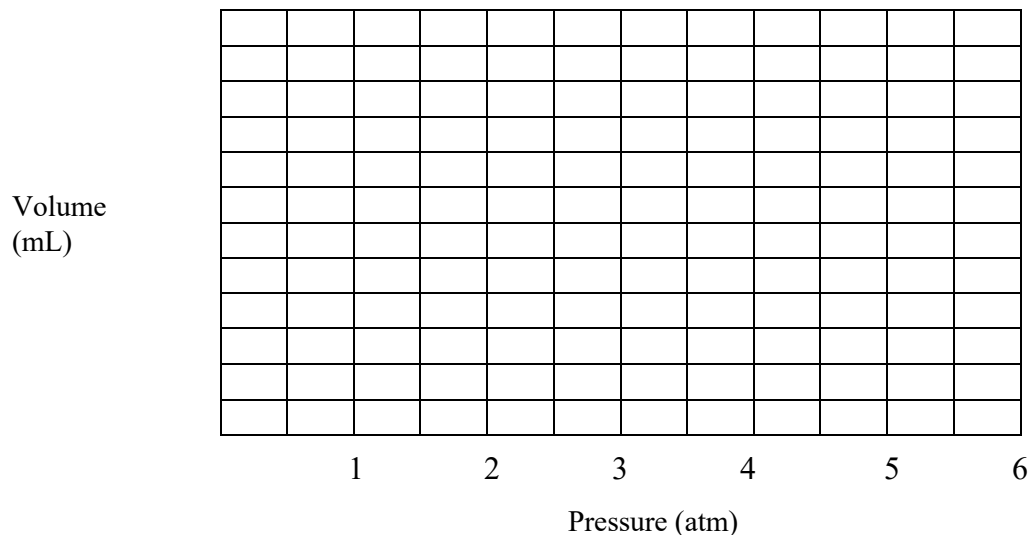
1. A helium balloon initially inflated to 2.50L at 100 kPa and  $25.0^\circ\text{C}$  is released and allowed to climb to a new altitude where the temperature is  $10^\circ\text{C}$  and the pressure is 25 kPa.

a) What is the volume in litres of the balloon at this height? (2 marks)

b) If the balloon has a maximum inflation volume of 10.0 L, will the balloon explode at this new height? (1 mark)

2. A gas sample is held at constant temperature in a closed system. The volume of the gas is changed, which causes the pressure of the gas to change. Volume and pressure data are shown in the table below.

Volume (mL)	Pressure (atm)
1200	0.5
600	1.0
300	2.0
150	4.0
100	6.0



- a) On the grid provided, mark an appropriate scale on the axis labeled “Volume (mL)”. (1 mark)
- b) On the same grid, plot the points and connect your points with a smooth line. (1 mark)
- c) Based on your graph, what is the pressure of the gas when the volume of the gas is 200 mL? (1 mark)
- d) Using Boyle’s Law, calculate what final volume you would expect to find if your final pressure is 7 atm. You may choose any of the above sets of data to represent your initial pressure and volume. (1 mark)

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**III: Chemical Reactions (16 marks)**

1. A sample of krypton contains these isotopes.

Isotope	Percentage abundance
$^{82}\text{Kr}$	15.80
$^{84}\text{Kr}$	65.40
$^{86}\text{Kr}$	18.80

Calculate the relative atomic mass of krypton in this sample. Give your answer to **two** decimal places. All work must be shown for full marks. (2 marks)

2. Consider the reaction between aqueous hydrochloric acid (HCl) and solid calcium carbonate to produce water, carbon dioxide gas and aqueous calcium chloride.

**Hydrochloric acid + calcium carbonate → water + carbon dioxide + calcium chloride**

- a) Write a balanced chemical equation for the reaction (2 marks)
- b) As this reaction is studied over time, it is noticed that a loss in mass has occurred. Explain why. (1 mark)
- c) Another reaction occurs between calcium carbonate and iron (III) nitrate. Name and give the molecular formulas of the products in this double replacement reaction. (2 marks)

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3. An organic compound was analyzed and the following data were produced. In a 4.479 g sample;

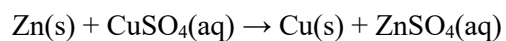
Mass of carbon = 3.161 g  
Mass of hydrogen = 0.266 g  
Mass of oxygen = 1.052 g

a) Calculate the empirical formula for the organic compound. (3 marks)

b) If analysis revealed that the molar mass of the compound is 136 g/mol, determine the molecular formula for the compound. (1 mark)

---

4. Consider the reaction between zinc and copper (II) sulphate.



- a) Assuming that 27.5 g of zinc was combined with a solution that contains 60.5 g of copper (II) sulphate, determine the limiting reagent. Show all work for full marks.

(3 marks)

- b) Calculate the mass of copper produced.

(1 mark)

- c) If 19.3 g of copper was **actually** collected in the lab, determine the percent yield.

(1 mark)

**IV: Solutions (10 marks)**

1. 5 g of sodium chloride, NaCl, is added to 50 ml of water in one beaker while 5 g of sugar, C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>, is added to 50 ml of water in another beaker.

a) Draw a molecular level diagram for each beaker. (2 marks)

b) Explain how the **two** solutes compare once dissolved in water. (2 marks)

c) State and explain how you would expect the boiling point of the two solutions to compare. (2 marks)





**V: Organic Chemistry (10 marks)**

1. Draw the following organic compounds. (1 mark each = 2 marks)

a) 3-ethyl-2,4-dimethylpent-2-ene (3-ethyl-2,4-dimethyl-2-pentene)

b) 2-methyl-butanoic acid

2. Use the following data table for this question.

**Formulas and Boiling Points  
Of Selected Alkanes**

Name	Formula	Boiling Point at 1atm (°C)
Methane	CH <sub>4</sub>	-162
Ethane	C <sub>2</sub> H <sub>6</sub>	-89
Propane	C <sub>3</sub> H <sub>8</sub>	-42
Butane	C <sub>4</sub> H <sub>10</sub>	-0.5
Pentane	C <sub>5</sub> H <sub>12</sub>	36

a) State and explain the trend in boiling points for the first 5 alkanes. (2 marks)

b) At standard pressure and 23°C, which alkane is a liquid? (1 mark)

3. Methyl butanoate is the ester responsible for an apples aroma.

a) Draw the structure of methyl butanoate. (1 mark)

b) Draw structures and name the **two** reactants responsible for producing methyl butanoate. (2 marks)

c) Write a complete reaction for the production of methyl butanoate. Be sure to include all conditions necessary for the reaction to take place. (2 marks)

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**PART B: MULTIPLE CHOICE (50 marks – 50% of exam mark)****I: Physical Properties of Matter**

- Which of the following descriptions is **true** for gases?
  - Easily compressible
  - Fast, random motion of particles
  - Perfectly elastic collisions between particles
  - I
  - I,II
  - II, III
  - I, II, III
- At STP, fluorine is a gas and bromine is a liquid because, compared to fluorine, bromine has
  - stronger bonds between the Br and Br atoms (covalent bonds).
  - stronger forces between the Br<sub>2</sub> molecules (intermolecular forces).
  - weaker bonds between the Br and Br atoms (covalent bonds).
  - weaker forces between the Br<sub>2</sub> molecules (intermolecular forces).
- In which sample of water do the molecules have the **highest** average kinetic energy?
  - 20.0 mL at 100°C
  - 40.0 mL at 80°C
  - 60.0 mL at 60°C
  - 80.0 mL at 40°C
- Which process is exothermic?
  - Boiling water
  - Melting copper
  - Condensation of ethanol vapor
  - Sublimation of iodine
- Which explanation **best** describes why an uncovered glass of water left on a counter over night will decrease in volume and temperature? Assume a constant **room temperature** of 22°C for the entire experiment.
  - Higher energy molecules will evaporate to the open system, thus decreasing the volume and average temperature.
  - The water molecules become packed closer together as the temperature of the water decreases, thus decreasing the volume because of the temperature loss.
  - The water molecules become more volatile as the atmospheric pressure over the glass of water increases allowing water to evaporate and lower the temperature.
  - The kinetic energy of the water increases because of the constant room temperature and this allows higher energy particles to escape to the atmosphere, thus lowering the temperature.

- 
6. Ethanol has a normal boiling point of  $78.3^{\circ}\text{C}$ , Diethyl ether has a normal boiling point of  $34.6^{\circ}\text{C}$  and water has a normal boiling point of  $100.0^{\circ}\text{C}$ . Which of the liquids listed would have the **highest** vapour pressure?
- A) Ethanol
  - B) Diethyl ether
  - C) Water
  - D) There is not enough information given.
7. A liquid will boil when the external pressure equals the vapour pressure of a liquid. Which of the following conditions are used to measure the STANDARD BOILING POINT?
- I.  $0^{\circ}\text{C}$
  - II.  $101.3\text{ kPa}$
  - III.  $700\text{ mmHg}$
  - IV.  $1\text{ atm}$
- A) I and II only
  - B) II and III only
  - C) II and IV only
  - D) I, II, III and IV

## II: Gases and the Atmosphere

8. Which of the following scientists studied the sum of partial pressures of gases in a system?
- A) Dalton
  - B) Boyle
  - C) Torricelli
  - D) Galileo
9. If a scuba tank has a pressure of  $2.5\text{ atm}$  on the pressure gauge, this would be the same as:
- I.  $253.25\text{ kPa}$
  - II.  $1900\text{ mm Hg}$
  - III.  $304\text{ mm Hg}$
- A) I only
  - B) II only
  - C) I and II only
  - D) I, II and III
10. A sample of nitrogen gas in an enclosed syringe originally occupies a volume of  $50\text{ mL}$  at  $101.3\text{ kPa}$ . If the syringe is depressed and the pressure increases to  $300\text{ kPa}$ , what will be the new volume? Assume that the temperature remains constant.
- A)  $0.06\text{ mL}$
  - B)  $607.8\text{ mL}$
  - C)  $16.9\text{ mL}$
  - D)  $148.1\text{ mL}$

11. The temperature at which the kinetic energy of a gas is zero is known as:

- I. Absolute zero
- II.  $-273\text{ }^{\circ}\text{C}$
- III.  $0\text{ K}$

- A) I only
- B) II only
- C) I and II only
- D) I, II and III

12. A gas in a non – rigid container (pressure remains constant) initially at  $200\text{ K}$  occupies a volume of  $2.75\text{ L}$ . If the gas is heated and the volume has changed to  $4.89\text{ L}$ , what was the **final** temperature of the gas?

- A)  $355\text{ K}$
- B)  $2690\text{ K}$
- C)  $405\text{ K}$
- D)  $135\text{ K}$

13. A rigid metal container (fixed volume) holds a sample of helium gas at  $400\text{ K}$  with a pressure of  $3.3\text{ atm}$ . Determine the pressure of the gas if the helium is heated to  $900\text{ K}$ .

- A)  $1.5\text{ atm}$
- B)  $7.4\text{ atm}$
- C)  $9.1\text{ atm}$
- D)  $11.8\text{ atm}$

14. An inflation bag is used to lift heavy items from deep under water. If the bag initially has a volume of  $1.0\text{ L}$  at  $3\text{ atm}$  of pressure and  $280\text{ K}$ , what would be the new volume of the bag at the surface of the lake if the pressure is  $1\text{ atm}$  and at a temperature of  $300\text{ K}$ ?

- A)  $3.21\text{ L}$
- B)  $28000\text{ L}$
- C)  $280\text{ L}$
- D)  $2.8\text{ L}$

### III: Chemical Reactions

15. Silicon has three isotopes that occur in nature,  $^{28}\text{Si}$ ,  $^{29}\text{Si}$  and  $^{30}\text{Si}$ . Which is the **most** abundant isotope in nature?

- A)  $^{28}\text{Si}$
- B)  $^{29}\text{Si}$
- C)  $^{30}\text{Si}$
- D) There is not enough information given.

16. Which of the following is the **correct** formula for iron (III) sulphate?

- A)  $\text{FeSO}_4$
- B)  $\text{Fe}_3(\text{SO}_4)_2$
- C)  $\text{Fe}_2(\text{SO}_4)_3$
- D)  $\text{Fe}_3\text{SO}_4$

17. What is the **correct** atomic mass of lead (II) chromate,  $\text{PbCrO}_4$ ?

- A) 235.2 amu
- B) 275.2 amu
- C) 323.2 amu
- D) 339.2 amu

**Use the following information to answer questions 18 and 19.**

Iron and aqueous copper (II) nitrate will combine to produce copper and aqueous iron (III) nitrate.

18. Which of the following represents the **correct** balanced equation to represent the reaction?

- A)  $3\text{Fe}(\text{s}) + \text{Cu}_2\text{NO}_3(\text{aq}) \rightarrow 2\text{Cu}(\text{s}) + \text{Fe}_3\text{NO}_3(\text{aq})$
- B)  $\text{Fe}(\text{s}) + \text{CuNO}_3(\text{aq}) \rightarrow \text{Cu}(\text{s}) + \text{FeNO}_3$
- C)  $\text{Fe}(\text{s}) + \text{Cu}(\text{NO}_3)_2 \rightarrow \text{Cu}(\text{s}) + \text{Fe}(\text{NO}_3)_3$
- D)  $2\text{Fe}(\text{s}) + 3\text{Cu}(\text{NO}_3)_2 \rightarrow 3\text{Cu}(\text{s}) + 2\text{Fe}(\text{NO}_3)_3$

19. What type of reaction does this **best** represent?

- A) Synthesis
- B) Decomposition
- C) Single replacement
- D) Double replacement

20. What are the products from the decomposition reaction of calcium carbonate,  $\text{CaCO}_3$ ?

- I. Calcium
  - II. Carbon dioxide
  - III. Calcium oxide
- A) I and II only
  - B) II and III only
  - C) I and III only
  - D) I, II and III

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21. Which of the following statements about the mole are **correct**?

- I. The formula mass, expressed in grams, represents the mass of one mole of that substance.
- II. One mole of any substance contains  $6.02 \times 10^{23}$  particles.
- III. One mole of any gas, at STP conditions, occupies 22.4 liters.

- A) I and II only
- B) II and II only
- C) I and III only
- D) I, II and III

22. What is the mass of  $\frac{1}{2}$  mole of calcium chloride,  $\text{CaCl}_2$ ?

- A) 111 g
- B) 55.5 g
- C) 75.5 g
- D) 37.8 g

23. One mole of oxygen gas has a mass of 32 g and occupies a volume of 16.4 L at 300 K and 151.95 kPa. Determine the density of oxygen gas under these conditions.

- A) 1.95 g/L
- B) 0.52 g/L
- C) 52.4 g/L
- D) 19.5 g/L

24. How many molecules are present in  $2.0 \times 10^{-21}$  mol of molecules?

- A)  $2.0 \times 10^{-21}$
- B)  $1.2 \times 10^3$
- C)  $6.0 \times 10^{23}$
- D)  $3.0 \times 10^{44}$

25. How many moles of carbon dioxide are present in an 88 g sample?

- A) 0.5 mol
- B) 1.0 mol
- C) 2.0 mol
- D) 3.1 mol

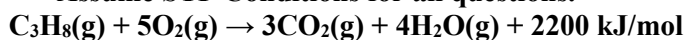
26. Which of the following has/have the empirical formula  $\text{CH}_2\text{O}$ ?

- I.  $\text{C}_2\text{H}_4\text{O}_6$
- II.  $\text{C}_6\text{H}_{12}\text{O}_6$
- III.  $\text{CH}_3\text{COOCH}_3$

- A) I and II only
- B) II and III only
- C) I and III only
- D) I, II and III

**Consider the following equation for questions 27 through 30.**

**Assume STP Conditions for all questions.**



27. If 15 moles of oxygen are available with excess propane, how much water would be produced?

- A) 18.75 mol
- B) 12.00 mol
- C) 9.00 mol
- D) 25.00 mol

28. If 3 moles of propane are allowed to react with excess oxygen, how much heat would be produced in this reaction?

- A) 6600 kJ
- B) 2200 kJ
- C) 3666 kJ
- D) 1320 kJ

29. If 3 mol of propane reacts with 4 mol of oxygen, which reactant would limit the amount of products and how much water (in mol) would be produced in this reaction?

- A) Propane, 0.75 mol
- B) Propane, 12 mol
- C) Oxygen, 3.2 mol
- D) Oxygen, 5 mol

30. In another reaction, an actual yield of 45 g of carbon dioxide is produced. Determine the percent yield if a theoretical yield of 135 g was expected.

- A) 3%
- B) 33%
- C) 59%
- D) 87%



**IV: Solutions**

31. Which of the following **best** explains why water will dissolve many ionic compounds?
- A) Ionic compounds have very weak bonds between the atoms.
  - B) Water is a polar covalent compound and has the ability to separate some ionic compounds into the ions that make it up.
  - C) Water is an ionic compound and “like will dissolve like”.
  - D) Water has very weak bonds that hold it together.
32. Which of the following descriptions **best** describes an unsaturated solution?
- A) A solution that contains the maximum amount of solute that will dissolve in a given solvent at a specific temperature.
  - B) A solution that contains less solute than it has the capacity to dissolve.
  - C) A solution that contains more solute than is present in a saturated solution.
  - D) None of the above.

**Use the solubility curves in your data booklet for questions 33 and 34.**

33. What mass of cerium sulphate,  $\text{Ce}_2(\text{SO}_4)_3$  is used to prepare a saturated solution with 250 ml of water at 20° C?
- A) 10 g
  - B) 20 g
  - C) 25 g
  - D) 30 g
34. A saturated solution of sodium nitrate,  $\text{NaNO}_3$ , is prepared at 20°C in 100 ml of water. If the solution is heated to 50°C, how much more sodium nitrate would need to be added to maintain a saturated solution?
- A) 28 g
  - B) 87 g
  - C) 115 g
  - D) 143 g
35. Which of the following conditions would allow the **greatest** amount of  $\text{CO}_2(\text{g})$  to dissolve in water?
- A) 20°C and 1 atm of pressure above the surface of water.
  - B) 10°C and 2 atm of pressure above the surface of water.
  - C) 5°C and 3 atm of pressure above the surface of water.
  - D) 20°C and 3 atm of pressure above the surface of water.

- 
36. Which of the following compounds, when added to water, would **increase** the boiling point the **most**?
- A)  $C_6H_{12}O_6$
  - B) NaCl
  - C)  $CaCl_2$
  - D)  $AlCl_3$
37. Sensodyne toothpaste contains 5 % w/w potassium nitrate for sensitive teeth. Which of the following would be an accurate description of the concentration of potassium nitrate in sensodyne?
- A) If the toothpaste tube is 100ml, 5% is potassium nitrate.
  - B) There are 5 g potassium nitrate in 100g of toothpaste.
  - C) Sensodyne is a concentrated solution of potassium nitrate.
  - D) There are 5g potassium nitrate in 95g of toothpaste.
38. A 150 mL solution of NaCl with a concentration of 0.1 mol/L needs to be prepared. How many moles of NaCl are needed?
- A) 1.5 mol
  - B)  $6.67 \times 10^{-4}$  mol
  - C) 1500 mol
  - D) 0.015 mol
39. A solution of silver nitrate  $AgNO_3$  is to be prepared using 2.123 g of silver nitrate. If the desired concentration is 0.5 mol/L, what volume (in ml) of distilled water must be used to make the solution?
- A) 4.25 ml
  - B) 0.025 ml
  - C) 25.00 ml
  - D) 200.00 ml
40. A student gathers 10 ml of a 6 mol/L solution of nitric acid,  $HNO_3$ . The student has to dilute the solution to a concentration of 1.5 mol/L. How much distilled water needs to be added to the original 10 ml?
- A) 30 ml
  - B) 40 ml
  - C) 50 ml
  - D) 60 ml
-

**V: Organic Chemistry**

41. Which of the following is/are not organic compounds?

- I.  $\text{CO}_2$
- II.  $\text{CH}_3\text{COOH}$
- III.  $\text{NH}_3$

- A) I and II only
- B) II and III only
- C) I and III only
- D) I, II and III

42. How many double bonds is each carbon atom capable of holding?

- A) 1
- B) 2
- C) 3
- D) 4

43. An increase in all but one of the following will result in an increase in boiling point when considering alkanes.

- A) Chain length
- B) Number of side chains
- C) Molar mass
- D) Number of carbons present

44. Which of the following represents a hydrogenation reaction that could take place with a platinum catalyst?

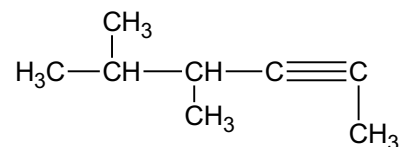
- A)  $\text{CH}_2=\text{CH}_2 + \text{H}_2 \rightarrow \text{CH}_3\text{CH}_3$
- B)  $\text{CH}_3\text{CH}_3 + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{CH}_2\text{OH} + \text{H}_2$
- C)  $\text{CH}_3\text{CH}_3 \rightarrow \text{CH}_2=\text{CH}_2 + \text{H}_2$
- D)  $\text{CH}_3\text{COOH} + \text{CH}_3\text{OH} \rightarrow \text{CH}_3\text{COOCH}_3 + \text{H}_2\text{O}$

45. Which of the following hydrocarbons is/are saturated?

- I.  $\text{CH}_2\text{CHCH}_3$
- II.  $\begin{array}{c} \text{H}_3\text{C}-\text{CH}_2-\text{CH}-\text{CH}_3 \\ | \\ \text{CH}_3 \end{array}$
- III.  $\text{H}_3\text{C}-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_3$

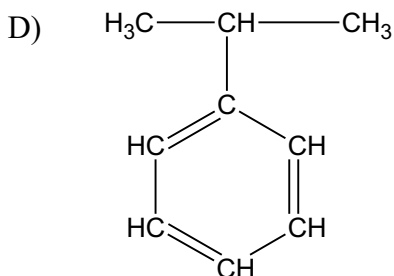
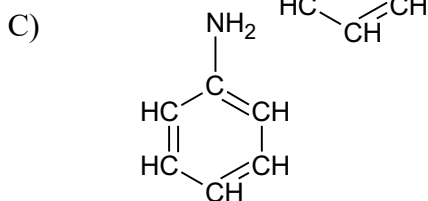
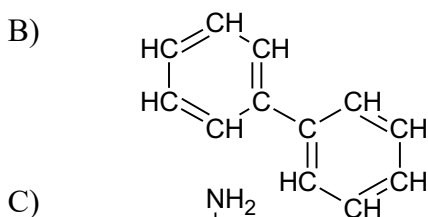
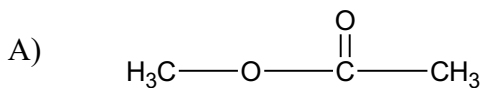
- A) I only
- B) II only
- C) II and III only
- D) I and III only

46. What is the name of the organic compound below?

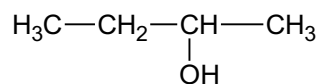


- A) 1,3,4-trimethylpent-2-yne (1,3,4-trimethyl-2-pentyne)  
 B) 2,3,5-trimethylpent-2-yne (2,3,5-trimethyl-2-pentyne)  
 C) 2,3-dimethylhex-2-yne (2,3-dimethyl-2-hexyne)  
 D) 4,5-dimethylhex-2-yne (4,5-dimethyl-2-hexyne)

47. Which of the following is an aliphatic hydrocarbon?



48. What is the name of the alcohol below?



- A) Butan-2-ol (2-Butanol)  
 B) Butan-3-ol (3-Butanol)  
 C) Pentan-2-ol (2-Pentanol)  
 D) Pentan-3-ol (3-Pentanol)

49. Which of the following can form an addition polymer?

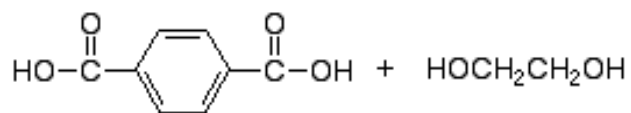
- A) Butane
- B) But-2-ene
- C) 1,2-dichlorobutane
- D) methanol

50. Which of the following polymers is/are prepared through **condensation polymerization**? The monomer units are shown.

I. Polyvinyl chloride



II. Polyester



III. Polyethylene



- A) I only
- B) II only
- C) I and III only
- D) I, II, and III