Chemistry III

015

10/07/2025 2:00 PM – 3:30 PM

NESA NATIONAL EXAMINATION AND SCHOOL INSPECTION AUTHORITY

ADVANCED LEVEL NATIONAL EXAMINATION, 2024-2025

SUBJECT: CHEMISTRY

PAPER III: ALTERNATIVE TO PRACTICAL EXAMINATION

COMBINATIONS:

- BIOLOGY-CHEMISTRY-GEOGRAPHY **(BCG OLD)**
- MATHEMATICS-CHEMISTRY-BIOLOGY **(MCB OLD)**
- PHYSICS-CHEMISTRY-BIOLOGY **(PCB OLD)**
- PHYSICS-CHEMISTRY-MATHEMATICS **(PCM OLD)**

DURATION: 1 HOUR 30 MINUTES

Instructions to candidates:

1) Write your names and index number on the answer booklet as written on your registration form.
2) **DO NOT** open this question paper until you are told to do so.
3) This paper consists of **one compulsory** question. **(30 marks)**
4) All answers should be written in the spaces provided in the question paper.
5) **You do not need the periodic table.**
6) For Multiple Choice Questions, **circle** a letter corresponding to the correct answer.
7) Use a **blue** or **black** pen for answering and a pencil for drawing

ALTERNATIVE TO PRACTICAL EXAMINATION

Chemistry is widely applied in daily life products. From small to large scale manufacturing, the applications of chemistry are experienced. Among the daily applications of chemistry, candle is an example of manufactured products.

1) You are provided with some alternative raw materials which are used in making candles. Study them and answer the questions that follow.

SN	Materials	Types	Chemical composition	Description
1	Wax	Paraffin Wax	Mixture of saturated straight-chain hydrocarbons, where $\mathbf{C_n}$ ranges from C_{20} to C_{40}.	Most common, cost-effective with a pleasant smell.
		Soy wax	It is made by hydrogenating soybean oil, converting its unsaturated fatty acids into saturated ones.	Natural, eco-friendly, burns cleaner and slower.
		Beeswax	Beeswax is a natural wax produced by honeybees, and composed of a complex mixture of long-chain alkanes, fatty acids, esters, and alcohols.	All-natural, subtle honey scent, burns longest.
		Palm Wax	A mixture of organic molecules such as fatty acids, esters, and long-chain hydrocarbons derived from palm oil.	It is a crystalline finish, renewable, and harder wax.
		Coconut Wax	A mixture of organic molecules such as fatty acid esters (triglycerides) and long-chain hydrocarbons derived from coconut oil.	Soft, clean-burning, often blended with soy.
2	Wick (thread)	Cotton wicks		Most common, lead-free, braided.
		Wood wicks		Provide crackling sound, trendy aesthetic.
		Hemp wicks		Eco-friendly, steady burn.

3	Fragrance oils (or Essential oils)	Fragrance oils		Synthetic or blended oils; better hot/cold throw.
		Essential oils		Natural but usually lighter scent and more expensive.
4	Colorants (dyes)	Liquid candle dye		Easy to mix, vibrant results.
		Natural colorants		Herbs or clays (less vibrant, may affect burning).
5	Containers or molds	Glass jars, ceramic containers		For container candles.
		Silicone or metal molds		For pillar or shaped candles.

The choice of this or that type of material is dependent on either its availability to the manufacturing industry or the benefits it provides.

There are some tools and equipment which are necessary but which are alternatively used depending on the level of the manufacturing industry.

- Stove/boiler or melting pot
- Thermometer
- Stirring stick (Wood/bamboo)
- Pouring pitcher
- Wick holders or centering tools
- Storage racks
- Cutter
- Weighing scale

2) Procedure for candle making

i) Measure the desired amount of wax using a weighing scale (approximately 1 kg).

ii) Melt the wax using a heater maintaining a temperature not more than 70-80^{0}C to avoid degradation of the wax.

iii) Prepare the glass containers by securing the wicks at the center and ensuring they remain upright during pouring.

iv) Add approximately 10 mL of essential oil to the melted wax for fragrance.

v) Once the wax reaches the approximate temperature, carefully pour it into the prepared containers.

vi) Allow the candles to cool and solidify at room temperature for several hours.

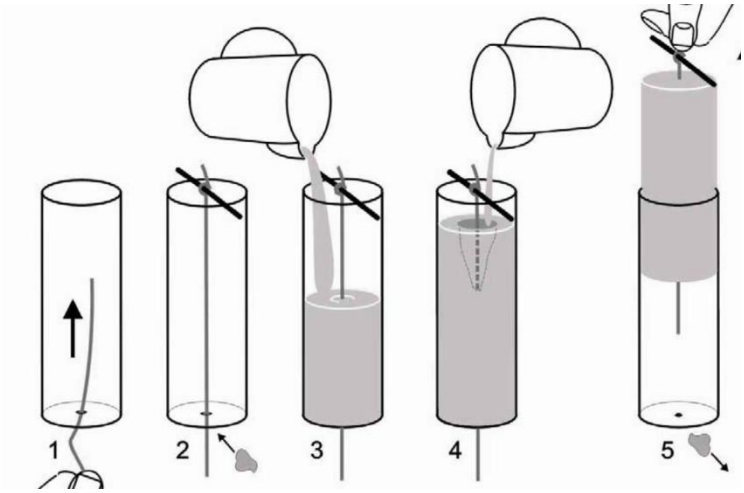


Figure: Candle making process

3) Science behind the candle making and use

i) When making the candle:

The solid wax is first converted into liquid and it solidifies again after the candle is made.

ii) When using the candle:

Both the wax and the wick are burnt through a certain chemical reaction:

- For the wax in general:

$$\text{Wax} + \text{Oxygen} \longrightarrow \text{Carbon dioxide} + \text{Water} + \text{Energy (heat + light)}$$

- Specifically, for a hydrocarbon wax:

$$C_nH_{2n+2} + \left(\frac{3n+1}{2}\right)O_2 \longrightarrow nCO_2 + (n+1)H_2O + \text{Energy (heat + light)}$$

When the wick is lighted, the initial heat from the lighter melts the solid wax around the wick, turning it into a liquid. This liquid travels up through a process known as *capillary action*. As the liquid wax reaches the hottest part of the wick, near the flame, the intense heat causes it to turn into a hot gas.

Once the wax in gaseous state mixes with oxygen from the surrounding air, the high temperature of the flame provides the activation energy needed to start the chemical reaction. The bonds within the wax and oxygen are broken while the new bonds are formed in carbon dioxide (CO_2) and water (H_2O).

4) Questions to be responded

i) What are the two phase changes that mainly occur during the candle-making process? **(1 mark)**

A) Evaporation and condensation
B) Melting and solidification
C) Sublimation and deposition
D) Freezing and vaporization

ii) What two phase changes that occur when a candle burns? **(1 mark)**

A) Condensation and freezing
B) Sublimation and deposition
C) Freezing and sublimation
D) Melting and vaporization

iii) Which specific type of chemical reaction occurs when candle wax burns? **(1 mark)**

A) Decomposition reaction
B) Neutralization reaction
C) Combustion reaction
D) Precipitation reaction

iv) "During the burning of candle, "**x"** absorbs the melted wax through the *capillary action* process and draws it up to the flame, allowing the candle to burn continuously". Which of the following materials is "**x"** in the candle composition? **(1 mark)**

A) Wick
B) Essential oil
C) Colorant
D) Mold

v) Give the chemical formula of a saturated hydrocarbon wax molecule whose **n** is equal to 25. **(1 mark)**

A) $C_{25}H_{50}$
B) $C_{25}H_{52}$
C) $C_{25}H_{48}$

D) $C_{25}H_{54}$

vi) Soy wax, a vegetable-based wax is composed of triglycerides (fats) which are esters formed from fatty acids (mostly stearic, oleic, and palmitic acid) and glycerol ($CH_2(OH)$-$CH(OH)$-CH_2OH).

a) What is the correct systematic IUPAC name for glycerol? **(2 marks)**

A) 1,2,3-Propanoltriol

B) 3,3,3-Trihydroxypropane

C) Glycerin-1,2,3

D) Propane-1,2,3-triol

b) The general molecular formula for saturated fatty acids is $C_nH_{2n}O_2$. Stearic acid is a saturated fatty acid with C_{18}. What is the correct formula for stearic acid? **(2 marks)**

A) $C_{17}H_{33}COOH$

B) $C_{17}H_{31}COOH$

C) $C_{17}H_{35}COOH$

D) $C_{17}H_{29}COOH$

c) Oleic acid is a monounsaturated fatty acid (Octadec-9-enoic acid) with C_{18}. What is the correct structural formula for oleic acid? **(2 marks)**

A) $CH_3CH=CH(CH_2)_{14}COOH$

B) $CH_3(CH_2)_7CH=CH(CH_2)_7COOH$

C) $CH_3(CH_2)_7CH_2CH(CH_2)_7COOH$

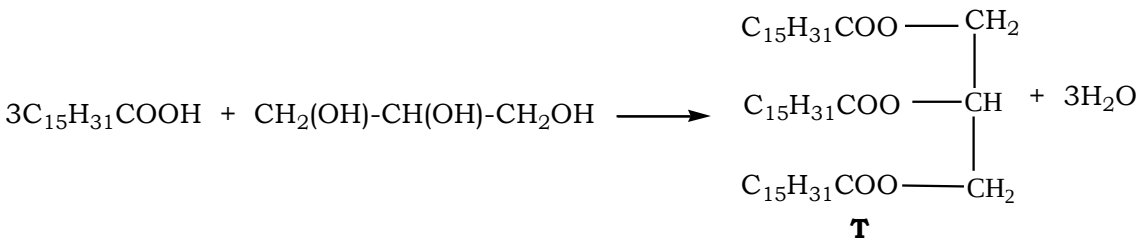
D) $CH_3(CH_2)_5CH=CH(CH_2)_7COOH$

vii) Upon burning a candle, several chemical reactions occur depending on its composition. Balance the following chemical equations with the appropriate products and stoichiometric coefficients.

a) $C_{20}H_{42} + O_2 \longrightarrow$ _____ + _____ **(2 marks)**

b) $C_{15}H_{29}COOH + O_2 \longrightarrow$ _____ + _____ **(2 marks)**

viii) A triglyceride **T**, is formed when the fatty acid ($C_{15}H_{31}COOH$) combines with glycerol ($CH_2(OH)$-$CH(OH)$-CH_2OH) according to the following equation:



T

[Given atomic masses: H =1, C =12, O = 16]

a) Determine the molar mass for the fatty acid, $C_{15}H_{31}COOH$. **(2 marks)**

b) Calculate the molar mass for the triglyceride **T**. **(2 marks)**

c) Calculate the mass of **T** produced when 38.4 grams of the fatty acid $C_{15}H_{31}COOH$ is used**.** **(3 marks)**

ix) You are provided with paraffin wax and soy wax as two types of raw materials to make candles. Which of the two would be preferred if one wanted to make candles with relatively minimal negative impact to the environment. **(2 marks)**

Explain your answer in (ix) above. **(2 marks)**

x) When melting the wax during candle making, it is recommended that the temperature must NOT go above 80^0C. Explain why. **(2 marks)**

xi) It is documented that candles have been utilized for centuries for various purposes. Suggest any two uses of candles in the society. **(2 marks)**

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