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Techniques for Writing Learning Objectives in Teaching Chemistry in High School

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Abstract Determining the learning objectives clearly is to show the teacher's responsibility and commitment to the learners according to the published subject program. On the basis of specific goals, teachers easily design lessons to help students develop the necessary competencies. Based on Bloom's cognitive levels, we have proposed verbs as well as learning objective writing forms for teachers to refer to. From that applying for the specific lesson plan "Alcohol" belongs to high school chemistry program in Vietnam including: (1) objectives, (2) plan of teaching, (3) worked examples and (4) homework. The results of analyzing pedagogical experimental data on high school students show that designing teachers' teaching goals has a great influence on deciding the success of the lesson. Comparison before and after the impact of designing goals on learning outcomes of learners shows the feasibility of the study.

Keywords: *learning objective, Bloom's verbs, SMART rule, teaching chemistry, plan of lesson, high school*

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1. Introduction

Objective (goal) is the expected result to be achieved after performing an activity.

Teaching objectives are the target learners must achieve after learning; that is the last "destination" that teachers and students have to aim for [1,2].

The learning objective (lesson goal or lecture objective) has many expressions such as: (i) The learning objective is the result that the teacher wants the learner to achieve after the lecture; (ii) Learning objectives "are statements about what learners must understand, must do after the lecture"; (iii) The goal is about what the learner will be like or be able to do after finishing a lecture.

These terms are used in a technical sense and it is important for all teaching staff to be aware of their meanings. Broadly speaking, all educational purposes can be defined in one of two ways:

(a) What it is intended that the teacher will do (an aim or a teacher-driven objective);

(b) What it is intended that the student will have learnt, or will be able to do, as a result of a learning experience, (an objective or learning outcome).

In the past, objectives have often been defined in terms of the teacher's activity; ie corresponding to definition (a) above. This is no longer adequate because teaching objectives need to be defined in terms of the ultimate purpose - student learning [3].

Thus, from the perspective of "learner-oriented teaching", the target is that of the learner, not the teacher. Therefore, the statement of the learning objective is always: *By the end of the lesson student will be able to ...*

Teaching goals in general and lectures in particular have a very important meaning, it not only guides and helps plan for teaching activities and when implemented will determine the success of this plan; but also the orientation for finding teaching materials; is the basis for determining the learning outcomes to be achieved, to test and evaluate learners, teachers as well as the value of a lecture, a training program.

Wesolowski's research has mentioned the concept student learning objectives (SLOs) were one of the areas of concern to district leaders, principals, and especially teachers. While there was an agreement from all groups that accountability should be equitable across all courses and disciplines, there was much trepidation about the SLO documents, targets, and process [4]. According to Suskie [5] SLOs are the ''knowledge, skills, attitudes, and habits of mind that students take with them from a learning experience''. SLOs set the tone for the class and relay expectations for student outcomes [6].

No lectures were effective but lacked a lesson goal. A lesson that lacks a goal or is incorrectly defined and unclear is like a boat going out to sea without determining the destination, not knowing where you are going, unaware of how to reach the destination, not knowing when to go to the destination and sometimes going through it without knowing it.

a) For teachers

A clear, complete, specific and exact goal will help teachers select and organize lesson content appropriately.

Learning objectives guide the next steps in the lesson plan; Based on the goal, select the content, method and form of teaching organization to give the best results.

The learning objectives are the basis for teachers to develop questions, tests and forms of tests to assess learners 'cognitive status, measure students' capacity after lectures or subjects; is the basis for teachers to assess the progress of students to what extent according to the set standards.

Targeted teaching will help teachers be confident and responsible in the process of teaching, thereby creating passion and interest in careers.

b) For learners

The learner understands the goal of the lesson that the teacher will determine the destination that he needs to be in the course of studying the subject, the lesson, ... From there, the learner knows how to choose learning materials, how to learn, organize your own learning process in a clear direction to achieve the goals set out.

Learners know the standard for self-comparison, assessing their own progress in learning.

Achieving the goal of the lecture will develop in learners intellectual abilities, thinking qualities, action skills, attitude formation and passion for the subject and therefore develop capacity for learners.

2. Requirements for Learning Objectives

The goal of the lecture must be expressed according to the learner's requirements, not the teacher's function.

The learning objectives must be appropriate (important, practical, appropriate), feasible (can be done) or in other words, when designing lesson objectives, it must ensure the "SMART" rule [7,8,9]:

S	Specific
M	Measurable
A	Attainable/Achievable
R	Relevant
T	Time-Bound

The learning objectives must be expressed in *an action verb means only single* (understandable and understood uniformly) and focus on results: (1) Expected results must be expressed in the form of observable (measurable) behavior; (2) Determine the behavioral situation that will take place: time and conditions for implementation; (3) Must be suitable for learners (psychological physiological characteristics and existing qualifications of learners).

3. Techniques for Writing Learning Objective

The learning objectives include: Knowledge, Skills, Attitudes (KSA).

The learning objectives must be written from the perspective of learners and begin with an action verb corresponding to the levels of knowledge mastering and having the complement to clarify the meaning for that verb. Non-measurable general verbs should not be used to write goals such as know, understand, master, be able, think, equip students, etc.

Opening the lesson goal is always "After completing the lesson (lecture), learners are capable of "knowledge", "skill", "attitude". Often use Bloom's verbs to write goals.

According to Benjamin S. Bloom (1956), the cognitive scale (see Figure 1) consists of 6 levels [10,11]:

(1) Knowledge

• Definition: Knowing is the ability to recall information and events without necessarily understanding them.

• Initial verbs are often used: *recall, relate, reproduce, state, define, describe, identify, name, record, outline, present/represent, narrate, quote, list, affirm, test, arrange, collect, dublicate/repeat, recognize, select, etc.*

For example:

Describe the operation of the electrolyser.

List the factors that affect the equilibrium shift.

Represent atomic structure models.

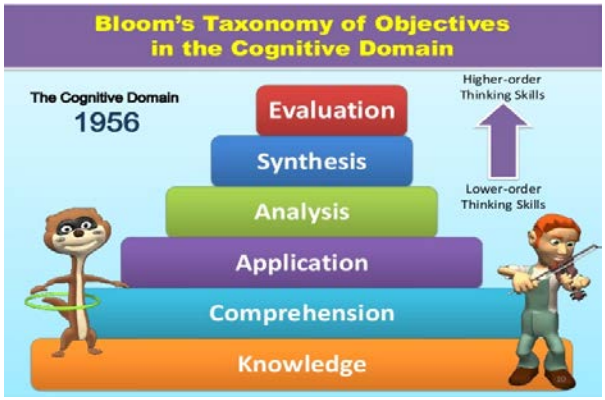


Figure 1. Bloom's Taxonomy

(2) Comprehention

• Definition: Understanding is the ability to understand the meaning of information and explain the information learned.

• Initial verbs are often used: *link, change, classify/categorize, interpret/clarify, create, distinguish, compare, arrange, contrast, decode, discuss, evaluate, explain, express, extend, generalize, give example, judge, infer, report, resolve, review, change, etc.*

For example:

Distinguish reactions occurring in the battery and in the electrolyte.

Explain the factors affecting reaction rate.

Discuss electrochemical corrosion.

(3) Application

• Definition: Application is the ability to apply knowledge to new circumstances, new situations, new conditions, and solve problems.

• Initial verbs are often used: *apply, evaluate, calculate, demonstrate, change, select, finish, construct, prove, develop, discover, exploit, check, recognize, illustrate, interpret, adjust, control, operate, organize, create, plan, perform, outline, sketch, etc.*

For example:

Outline of electric battery structure.

Apply of electrolysis to explain acid-base reaction.

Demonstrate the mechanism of metal corrosion in moist air environment.

(4) Analysis

• Definition: Analysis is the ability to divide information into elements to know their internal relationships and structure.

• Initial verbs are often used: *analyze, explain, appraise, arrange, subdivide, classify/ categorize, calculate, connect, compare, confirm, distinguish/differentiate, investigate, survey, ask questions, infer, etc.*

For example:

Compare the models of atomic structure.

Analyze the impact of the factors that increase the reaction rate.

Investigate the reactions that occur in the solution of electrolytes.

(5) Synthesis

• Definition: Synthesis is the capacity to link information together to create new ideas, to generalize the information that deduces consequences.

• Initial verbs are often used: *form/produce, design, develop, explain/demonstrate, establish, integrate, organize, reorganize, summarize, plan, etc.*

For example:

Summarize theories of atomic structure.

Design the model of electrolysis of sodium chloride solution.

Explain mechanisms of reactions occurring in solution.

(6) Evaluation

• Definition: Assessment is the ability to make judgments about the value of information, problems, things and phenomena in a specific purpose.

• Initial verbs are often used: *argue, defend, criticize, confirm, contact, appraise/assess, compare, explain, interpret, decide, judge, recommend, edit/repair/correct, summarize, approve, rate, support, predict, etc.*

For example:

Summarize Mendeleep's important contributions in laying the foundations of the periodic table.

Assess the role of the factors of equilibrium shift.

Predict the oxidation - reduction reactions that occur in solution.

4. Plan of Lesson: ALCOHOLS

Applying the above-mentioned learning objective techniques, we have designed a number of lessons in order for pedagogical experiment and bring some positive results. Below is an illustration of the chemistry lesson plan in Vietnam high school [12,13,14,15].

A. OBJECTIVES

By the end of the lesson student will be able to:

1. Define what alcohol is

2. Name the alcohol

3. Determine the structure of the alcohol and identify the functional group of alcohol

4. Describe the physical and chemical properties of alcohol

5. Describe the principles and methods of producing alcohol by fermentation

6. Apply alcohol oxidation reaction in your life

B. PLAN OF TEACHING

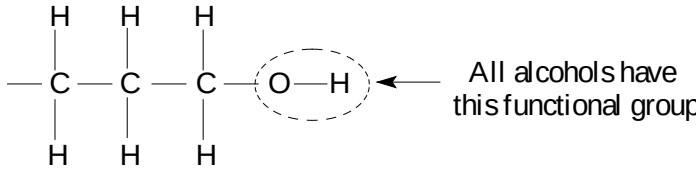
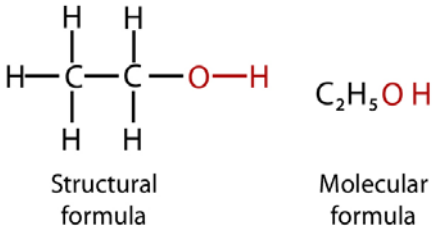
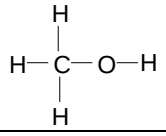
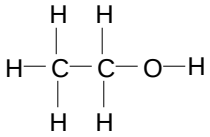
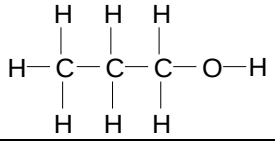
CONTENT	TEACHING ACTIVITIES
What are alcohols? In the previous lesson, you studied two homologous series: the alkanes and alkenes. The alcohols are another homologous series. • Alcohols are organic compounds which have the **hydroxyl** (-OH) functional groups connecting directly to their saturated carbon atoms.  • Structural and molecular formula of ethanol: 	**Activity 1. Learn about homologous series and structure of alcohol** Teachers organize group activities to learn about the definition of homologous series and the structure of alcohol. Some questions can be discussed: Q1. How is alcohol defined? Q2. What is the functional group of alcohol? Q3. How is the structure of alcohol? Q4. Who can draw structural and molecular formula of ethanol?
What is the general formula of acyclic saturated monoalcohols? All alcohols contain the elements carbon, hydrogen and oxygen. They have the general formula $C_nH_{2n+1}OH$.	**Activity 2. Determine the general formula of alcohol** The teacher suggests that students comment on the composition of the elements present in the alcohol and then find out the general formula of acyclic saturated monoalcohols.
Nomenclature of Alcohols The name of an alcohol ends with '-ol'. Hence, an alcohol that contains two carbon atoms is called ethanol. The fist three alcohols in the homologous series are given below.	**Activity 3. Introduction of alcohol naming rules** The teacher introduces the rule of calling the name of acyclic saturated monoalcohols. Then instruct the student groups to practice calling some alcohol names according to the Table 1.

Table 1. Name of some alcohols and their formulae

Name	Molecular formula	Structural formula	Full structural formula
Methanol	CH_3OH or CH_4O	CH_3OH	
Ethanol	C_2H_5OH or C_2H_6O	CH_3CH_2OH	
Propanol	C_3H_7OH or C_3H_8O	$CH_3CH_2CH_2OH$	

Physical Properties of Alcohols

The Table 2 shows the physical states, solubilities and boiling points of some alcohols.

Table 2. The physical properties of some alcohols

Alcohol	Physical state	Solubility in water	Boiling point (°C)
Methanol	liquid	very soluble	65
Ethanol	liquid	very soluble	78
Propanol	liquid	soluble	97
Butanol	liquid	slightly soluble	118

• Alcohols are soluble in water, but their solubility decreases as the molecular size increases. For example, methanol is very soluble in water but butanol is only slightly soluble in water.

• Unlike the alkanes and alkenes, the first four alcohols are liquids at room temperature.

Activity 4. Introduction of physical properties of alcohols

The teacher prepares the samples of some of the initial alcohols of homologous series. In order for students to observe their state and find out comments. The students conduct the experiment to comment on the solubility of these alcohols in water. The teacher organizes activities for students to predict the change in the boiling temperature of alcohol and draw the rule of change.

Chemical Properties of Alcohols

• Although alcohols contain the -OH group, they are not alkalis. In fact, they are all neutral.

• Alcohols are more reactive than alkanes because the C-O and O-H bonds in alcohols are more reactive than the C-C and C-H bonds in alkanes.

• The functional group (-OH) of alcohols is responsible for the typical reactions that alcohols undergo.

• All alcohols have similar chemical properties. Alcohols can take part in these reactions: combustion and oxidation.

Activity 5. Introduction of chemical properties of alcohols

The teacher organizes group activities for students to answer the questions:

Q1. Is the functional group (-OH) basic property?

Q2. Compare the polarization of the C-O and O-H bonds in alcohol with the C-C and C-H bonds in the alkane.

Q3. Considering the role of the OH-group, how does it influence the chemical properties of the alcohol?

Combustion

Like most other organic compounds, an alcohol such as ethanol burns in air to produce carbon dioxide and water vapour.

ethanol + oxygen $\xrightarrow{\text{heat}}$ carbon dioxide + water vapour

$C_2H_5OH\ (l) + 3O_2\ (g) \xrightarrow{\text{heat}} 2CO_2\ (g) + 3H_2O\ (g)$

The combustion of alcohols in excess oxygen produces a clean flame, as only carbon dioxide and water vapour are produced.

Activity 6. Learn about combustion of alcohol

The teacher guides students to burn ethanol:

Q1. Observe the flame and draw comments.

Q2. Write the chemical equation of combustion reaction.

How is the combustion of alcohols useful to us?

Alcohols can be used as a fuel. In fact, some race cars run on methanol. Methanol is less volatile than petrol and is less likely to explode in an accident. Methanol is also a clean fuel. It does not produce soot on combustion. Vietnam relies heavily on petrol as a fuel. Do you think it is good to use alcohol as a fuel instead?

Alcohol is also burnt on some foods such as fruit cake to give it a distinct flavor (see Figure 2).

Activity 7. Learn about application of the combustion of methanol

The teacher uses role-playing methods, creates a hypothetical situation, students play the role of a scientist who investigates customers using bio-petrol E5 methanol as an alternative fuel for RON 92 in Vietnam (see Figure 3).

Figure 3. Using bio-petrol E5 methanol in Vietnam

Then the teacher instructs the students to discuss and draw the comments

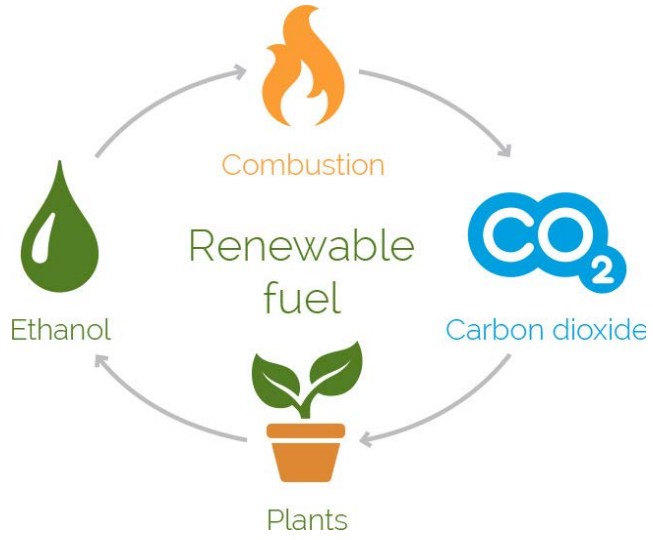


Figure 2. Renewable fuel

Oxidation

Alcohol are easily oxidised. For example, in the laboratory, we can oxidise ethanol by heating it with a mixture of potassium dichromate (VI) solution ($K_2Cr_2O_7$) and dilute sulphuric acid. Ethanol then becomes ethanoic acid (see Figure 4).

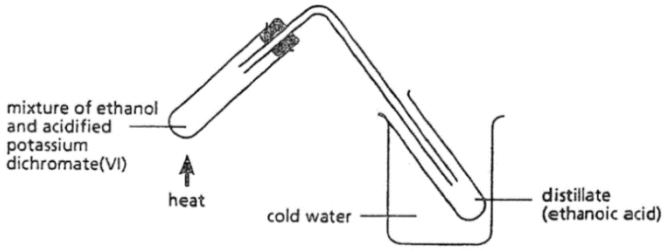
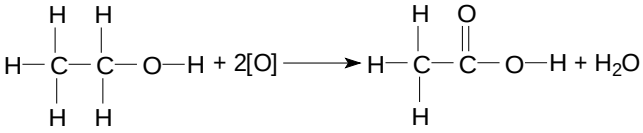


Figure 4. Oxidation of alcohol

ethanol + oxygen from oxidizing agent → ethanoic acid + water



In this redox reaction

a) ethanol acts as a reducing agent while acidified potassium dichromate (VI) acts as a oxidizing agent.

b) potassium dichromate (VI) is reduced. Its colour changes from orange to green.

c) ethanol is oxidized to ethanoic acid. Ethanoic acid is an example of a carboxylic acid. You will learn about carboxylic acids in the next section.

How is the oxidation of alcohols useful for us?

In Vietnam, the police use breathalysers to test the amount of alcohol consumed by drivers (see Figure 5). A brethalyser contains acidified potassium dichromate (VI). If the breath of a driver contains a high level of alcohol, a colour change is registered on the device.

Activity 8. Learn about oxidation of alcohol

Using the method of hands-on, teacher instructs students to practice ethanol oxidation experiment with a mixture of solution $K_2Cr_2O_7$ / H_2SO_4 (see Figure 4). Ask students to draw comments:

• Role of ethanol and $K_2Cr_2O_7$ / H_2SO_4 solution in the experiment.

• Color change of the $K_2Cr_2O_7$ agent during the reaction.

• Predict the product.

• Write reaction diagrams.

Activity 9. Learn about application of the oxidation of alcohols

The teacher introduces the principle of the Digital Alcohol Testing Device that traffic police often use to determine driver alcohol concentration (see Figure 5), requiring students to understand the mechanism of the device's operation.

Figure 5. Digital Alcohol Testing Device of Vietnamese traffic police

Producing Ethanol by Fermentation

To most people, alcohol refers to beverages like wine and beer. Actually, such drinks contain ethanol. To produce ethanol, we ferment fruits, vegetables or grains.

What is fermentation?

Fermentation is a chemical process in which microorganisms such as yeast act on carbohydrates to produce ethanol and carbon dioxide. Sugars and starch are examples of carbohydrates.

Yeast contains enzymes (biological catalysts) which cause starch or sugar to break down to glucose. The glucose is then broken down to ethanol and carbon dioxide.

A glucose solution is mixed with yeast and the mixture is kept at a temperature of about 37°C. Ethanol and carbon dioxide are produced after a few days.

glucose solution $\xrightarrow{\text{yeast}}$ ethanol + carbon dioxide

$C_6H_{12}O_6\,(aq) \xrightarrow{\text{yeast}} 2C_2H_5OH\,(aq) + 2CO_2\,(g)$

The enzymes in yeast work best at around 37^0C. If the temperature is above 37^oC, the enzymes will die and fermentation stops.

The fermentation of sugar produces only a dilute solution of ethanol (up to about 15%). This is because when the alcohol content exceeds this value, the yeast dies and fermentation stops. Ethanol can be obtained from this liquid mixture by fractional distillation.

In many countries, ethanol is manufactured by the fermentation of cane sugar. During fermentation, the sucrose ($C_{12}H_{22}O_{11}$) in the cane sugar is first converted to glucose, and then to ethanol and carbon dioxide. This ethanol is used as a fuel in cars!

Activity 10. Learn about producing ethanol by fermentation

The teacher prepares in advance groups of students to design learning projects "Producing Ethanol by Fermentation". Then ask the groups to present and guide students to discuss. Pay attention to the content and style of presentation and evaluation for the product points of the groups correctly and fairly.

What happens if alcoholic drinks are left exposed to air?

If an alcoholic drink such as wine or beer is left exposed to the air, it will turn sour after a few days. This is caused by the action of bacteria from the air. Using oxygen from the air, the bacteria oxidizes ethanol into ethanoic acid.

ethanol + oxygen from air $\xrightarrow{\text{bacteria}}$ ethanoic acid + water

$C_2H_5OH\,(aq) + O_2\,(g) \xrightarrow{\text{bacteria}} CH_3COOH\,(aq) + H_2O\,(l)$

It is therefore important that wine is kept tightly corked. This is also the reason why, when we are fermenting sugars to produce alcohol, it is important to ensure that fermentation takes place in the absence of air. Otherwise, the alcohol will be oxidized to form an acid called a carboxylic acid.

Activity 11. Learn about alcoholic drinks

The teacher organizes group discussions for students:

Q1. Why alcoholic beverages when exposed to air after a few days will turn into sour?

Q2. How to preserve alcoholic beverages so that they are not sour?

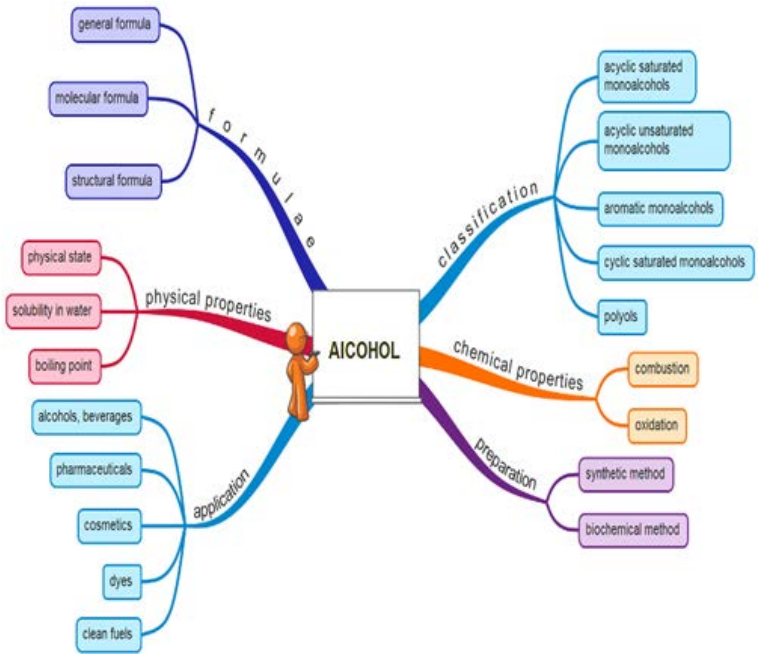


Figure 6. The mind map of alcohol

Activity 12. Consolidate the lesson

The teacher organizes the game for students to draw keywords (important terms in the lesson) and explain that word in English but cannot read the word so that the classmates say exactly that keyword. If the right player will be scored. The time of each play is not more than 2 minutes. With this lesson, teachers can prepare the following keywords:

ethanol, methanol, alcoholic, hydroxyl, fermentation, clean fuel, beverage, combustion of alcohol, oxidation of alcohol.

Finally the teacher summarizes the lesson with a mind map (see Figure 6).

C. WORKED EXAMPLES

Exercise 1. Ethanol vapour burns in air according to the following equation:

$$2C_2H_5OH(g) + 6O_2(g) \rightarrow 4CO_2(g) + 6H_2O(g).$$

If 2.5 L of ethanol burns at s.t.p., what volume of oxygen is required? What volume of carbon dioxide will be produced?

Solution:

$$2C_2H_5OH(g) + 6O_2(g) \rightarrow 4CO_2(g) + 6H_2O(g)$$

$$2.0L \quad 6.0L \quad 4.0L$$

$$2.5L \rightarrow 7.5L \rightarrow 5.0L$$

Exercise 2. Methanol is soluble in water. What is the molality of a solution made by dissolving 8.0 g of CH_3OH in 250 g of water?

Solution:

The mass of solution 8 + 250 = 258 (grams) $\rightarrow$ $C\%_{CH3OH\ solution} = \frac{8}{258}100 = 3.1\%$.

D. HOMEWORK

1. An alcohol has the molecular formula $C_4H_{10}O$.

a) Draw the full structural formula of this alcohol.

b) Give one physical property and one chemical property of this alcohol.

2. The figure here shows the apparatus used for fermentation (see Figure 7).

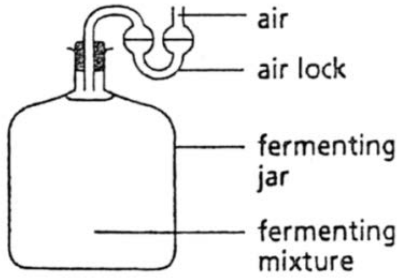


Figure 7. The apparatus used for fermentation

a) Name the substances present in the fermenting mixture.

b) Write the word equation for the reaction that takes place inside the apparatus.

c) Describe what will happen if the resulting mixture is exposed to air.

3. State two differences between the hydroxide group in sodium hydroxide and the hydroxyl group in alcohols.

5. Results and Discussion

The statistical criteria of the two experimental groups and the control groups also showed a big difference (see Table 3). The results in Table 3 show:

(i) The average value of the experimental group is high, the control group is 0.90 points with relatively small errors, variances and standard deviations, which proves high average values. The SE mean (0.096), the variance (0.618) and the standard deviation (0.779) of the experimental group are lower than the error (0.122), the variance (0.943) and the standard deviation (0.971) of the control group show the data of the experimental group were less dispersed than the control group, the average value was high, the data was reliable.

(ii) The largest and the smallest score of the experimental group were higher than the control group. This proves that the spectrum of post-impact testing score is higher than before.

(iii) Influence level (ES = 0.84), from ES value, look up Cohen table [16], showing that applying measures has a big impact on how to write learning objectives.

Table 3. Statistical criteria of experimental and control group

Inspection quantity		Control group	Experimental group
Value of the sample	Total	34	35
	Erroneous sample	0	0
Mean		6.81	7.71
Median		7.00	8.02
Mode		7.00	8.02
SE mean		0.122	0.096
Std. Deviation		0.971	0.779
Variance		0.943	0.618
Minium score		6	7
Maxium score		9	9
ES		0.84	

Thus, the calculation results show that the average score of the experimental group is higher than that of the control group, which indicates the experimental group with reduced dispersion and higher score spectra. To test the difference between the two mean values is meaningful, we rely on the following hypothesis:

Hypothesis H0: The average score between experimental and control groups is not significantly different.

Hypothesis H1: The mean score between the experimental and control groups is significantly different.

The results are determined by Independent Samples Test shown in Table 4.

Table 4 shows the significance of variance Sig. = 0.086 > 0.050 so the average value will be tested by equal variances assumed. Accordingly, with the meaning of observing 2 sides Sig.(2-tailed) = 0.000 < 0.050, rejecting the H0 hypothesis to accept hypothesis H1, ie, the average score of the experimental and control groups was significantly different with a 95% confidence level.

Table 4. Quantities of the summarized score average value of the experimental and control group

		Levene's Test for Equality of Variances		t-Test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
SCORE	Equal variances assumed	2.952	.086	5.142	132	.000	.801	.154	.486	1.107
	Equal variances not assumed			5.136	124.881	.000	.801	.166	.485	1.112

6. Conclusion

In fact teachers face many difficulties when determining the learning objectives to be achieved. Through studying how to write learning objectives, we have successfully applied to many chemistry lessons. Teachers mastering how to write learning objectives will design a teaching plan to develop students' abilities effectively. Clear learning objectives will guide teachers in developing appropriate teaching plans.

Acknowledgements

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