Teaching the Mole Concept

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Contents

- Mole concept in the syllabus
- Schedule in teaching/learning mole concept
- Trial run with the use of google form
  - Chemical equations
  - Calculations
    - Inter-conversions
    - Based on equations
    - Acid-base titrations
  - Experiments
- Responses from students
- Other remarks

Mole Concept in the syllabus (core)

- [Topic II: Chemical formulae]
- Topic III: Reacting masses
  - Mole, Avogadro’s constant, molar mass
  - Empirical formula, molecular formula
  - Reacting masses from chemical equations
- Topic IV: Volumetric analysis
  - Acid-base titrations
- Topic IX: Molar volume of gases
- + whenever chemical equations appear in the syllabus

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Schedule in teaching the mole concept

- After introducing Topic I
- Schedule:
  - Chemical formulae (Topic I)
  - Isotopic mass, atomic mass, molar mass
  - inter-conversions: mole, mass, number, volume
  - Writing chemical equations
  - Calculations based on chemical equations
  - Calculations based on volumetric analysis

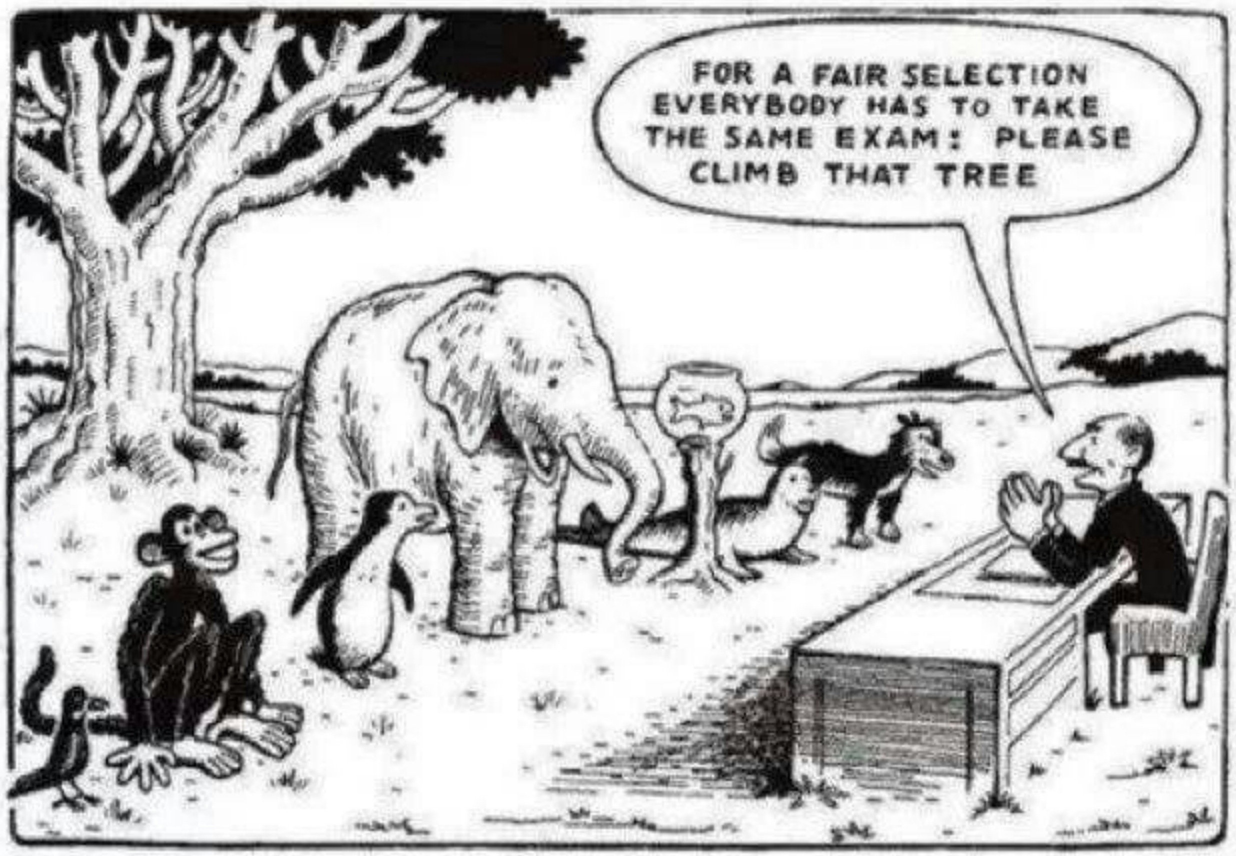
Teaching Schedule:

7 Cycles (6 x 35 minute-lessons per cycle)

Cycle	Contents	Exercise / Experiment
26/9 – 6/10	Isotopic mass, atomic mass, molar mass, mass percentage Introducing Mole Concept	
9/10 – 16/10	Mole concept calculations Calculations based on chemical equations	Practical 1
17/10 – 24/10	Writing chemical equations Further calculations based on chemical equations	Practical 2
25/10 – 3/11	Further calculations based on chemical equations	Practical 3
6/11 – 13/11	Volumetric Analysis I (Acid-baser titrations)	Practical 4
14/11 – 21/11	Volumetric Analysis II (Choice of indicators)	Practical 5
22/11 – 29/11	Volumetric Analysis III (Back titration)	Practical 6

Teaching mole concept in an early stage

- Can re-visit this topic later in the course
- As reported, students are weak in calculation
- Early diagnosis of the weakness in students when they perform calculations
- But, without studying electronic structure
  - May have difficulty in learning chemical formulae



Our Education System

"Everybody is a genius. But if you judge a fish by its ability to climb a tree, it will live its whole life believing that it is stupid."

- Albert Einstein

Cations			Anions		
Charge	Formula	Name	Charge	Formula	Name
1+	Na^+		1-	H^-	
	K^+			Cl^-	
	Cu^+			Br^-	
	Ag^+			I^-	
	Hg^+			OH^-	
	H^+			NO_3^-	
	NH_4^+			NO_2^-	
				HCO_3^-	
				HSO_4^-	
				CN^-	
				MnO_4^-	
				ClO_3^-	
				ClO^-	
2+	Mg^{2+}		2-	O^{2-}	
	Ca^{2+}			S^{2-}	
	Ba^{2+}			SO_4^{2-}	
	Pb^{2+}			SO_3^{2-}	
	Fe^{2+}			$S_2O_3^{2-}$	
	Co^{2+}			SiO_3^{2-}	
	Ni^{2+}			CO_3^{2-}	
	Mn^{2+}			CrO_4^{2-}	
	Cu^{2+}			$Cr_2O_7^{2-}$	

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Chemical equations

Equations mastered in Topic I:

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)/(g)$

$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$

[$2AgNO_3(aq) + Na_2CO_3(aq) \rightarrow Ag_2CO_3(s) + 2NaNO_3(aq)$

$2AgNO_3(aq) + Na_2SO_3(aq) \rightarrow Ag_2SO_3(s) + 2NaNO_3(aq)$

Ionic equations:

$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

$2Ag^+(aq) + CO_3^{2-}(aq) \rightarrow Ag_2CO_3(s)$

$2Ag^+(aq) + SO_3^{2-}(aq) \rightarrow Ag_2SO_3(s)$]

$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$

$Ca(OH)_2(s) + aq \rightarrow Ca(OH)_2(aq)$

$Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$

$CaCO_3(s) + CO_2(g) + H_2O(l) \rightarrow Ca(HCO_3)_2(aq)$

Further equations to be taught:

$C_xH_y + (x + y/4)\ O_2 \rightarrow xCO_2(g) + y/2\ H_2O$

$C_xH_yO_z + (x + y/4 - z/2)\ O_2 \rightarrow xCO_2(g) + y/2\ H_2O$

$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$ [also other alkali metals]

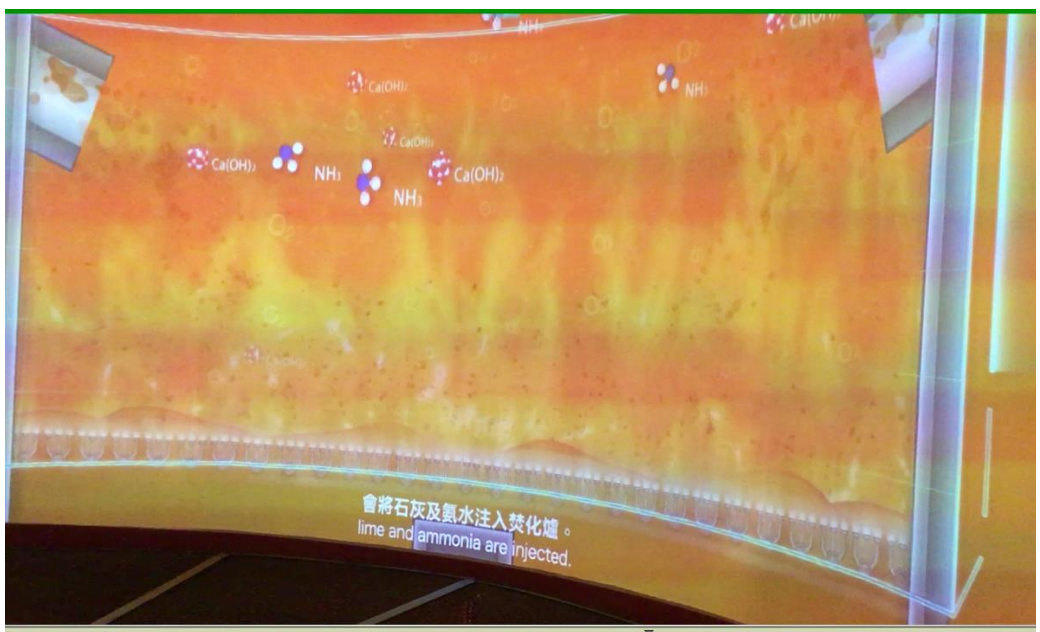
Displacement reactions

Chemical Equations

- Word equations to chemical equations
  - Requirement: with states written
- E.g. 1
  - Dilute hydrochloric acid reacts with sodium hydrogen carbonate solution giving carbon dioxide gas, water and sodium chloride solution.
- E.g. 2
  - Sodium hydroxide solution reacts with iron(II) sulphate solution forming a green precipitate of iron(II) hydroxide.

Trial run with the use of google form chemical equations

- T-park video:
  - Sludge from the water treatment plant mainly to T-park
  - A number of chemical reactions involved



Trial run with the use of google form

1) Name the 3 components of the fire triangle. (You may find the information from the first 50 seconds in the video.)

Short answer text

2) In the fire prevention literature, the term 'fire tetrahedron' is often mentioned. The fourth component is the chemical chain reaction initiated by free radicals (自由基). What do you understand by the term free radical? [Note that you will learn more about free radical in Topic V. For the time being, you have to search more information about free radical in the internet.]

Short answer text

Links for the above question:

https://www.firesafe.org.uk/information-about-the-fire-triangletetrahedron-and-combustion/ [For information on fire tetrahedron]
http://slideplayer.com/slide/7927691/25/images/6/Lewis+Structures+of+Free+Radicals.jpg [For information about free radicals]

Trial run with the use of google form

The following questions will concentrate on how nitrogen dioxide is removed from the gaseous air pollutants. [3'03" to 3'15"]

Description (optional)

4) Gaseous nitrogen oxides (NOx) are formed. The two oxides, nitrogen monoxide and nitrogen dioxide, are the constituents present in nitrogen oxides. Under high temperature, nitrogen and oxygen in air react forming nitrogen monoxide and finally nitrogen dioxide. Write the chemical equations involved.

Short answer text

5) Nitrogen dioxide reacts with water reversibly forming nitrous acid (HNO2) and nitric acid. Write a chemical equation for the reaction involved.

Short answer text

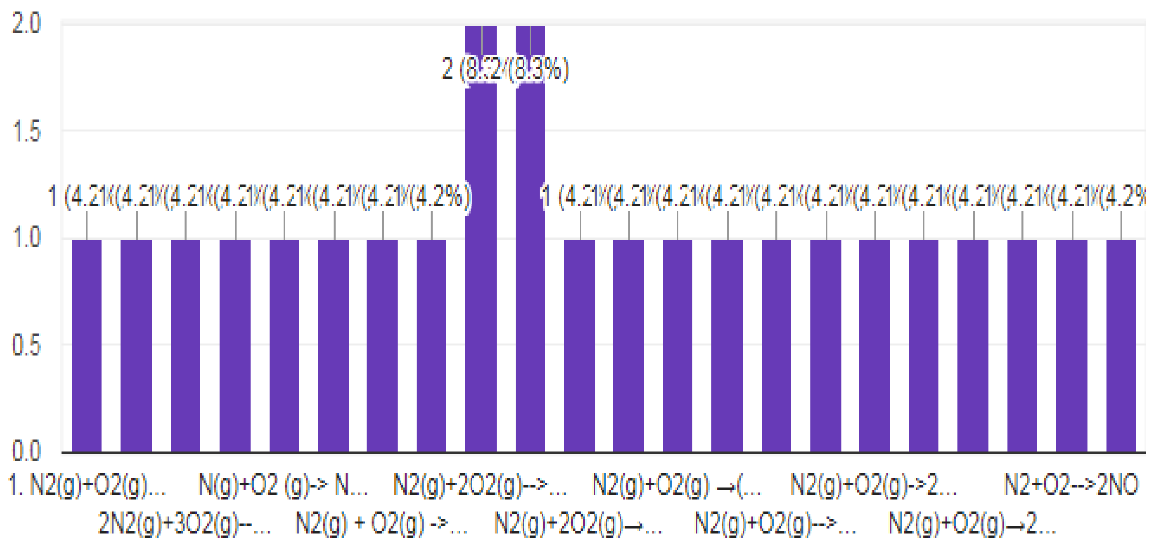
6) Aqueous ammonia is added to remove nitrogen dioxide. Ammonia reacts with nitrous acid and nitric acid forming aqueous ammonium nitrite and aqueous ammonium nitrate. Write a chemical equation for each reaction involved.

Long answer text

Trial run with the use of google form

4) Gaseous nitrogen oxides (NOx) are formed. The two oxides, nitrogen monoxide and nitrogen dioxide, are the constituents present in nitrogen oxides. Under high temperature, nitrogen and oxygen in air react forming nitrogen monoxide and finally nitrogen dioxide. Write the chemical equations involved.

24 responses



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Trial run - calculations

- Practice for the inter-conversions:
  - Mole, number, mass, volume
- Exercise 1 – Exercise 4

Trial run – Calculations based on chemical equations

- E.g.1 3.25 g of Zn is added to excess silver nitrate solution. Calculate the maximum mass of silver obtained.
- E.g.2 0.575 g of sodium is added to excess water. Calculate the volume of gas obtained under room conditions.
- E.g.3 When 1.00 g of calcium carbonate undergoes complete thermal decomposition. Calculate the theoretical mass of the residue and the volume of gas obtained under room conditions.

Trial run – Calculations involved in volumetric analysis

- E.g.1 On diluting a sample of ethanoic acid (CH_3COOH) five times, it was found that 25 cm^3 of the diluted solution required 30 cm^3 of 0.10 M sodium hydroxide solution for complete neutralization. What was the concentration of the original ethanoic acid in (a) mol dm^{-3} (b) g dm^{-3}?
- E.g.2 25.00 cm^3 of a 1.0 M solution of sodium hydroxide were placed in a flask. 1.40 g of an impure specimen of ammonium chloride was added. The flask and its contents were then carefully heated until no more ammonia gas was evolved. The resulting solution was found to be alkaline and was diluted to exactly 250.00 cm^3. 50.00 cm^3 of this solution required 5.10 cm^3 of 0.1 M hydrochloric acid for neutralization. Calculate the percentage purity of the original impure ammonium chloride.

Contents

Trial run with the use of google form - Experiments

- Practical 1: Stoichiometry: thermal decomposition of baking powder
- Practical 2: Displacement reaction
- Practical 3: Titration involving HCl(aq) and $NaHCO_3$(aq)]
- Practical 4: Titration involving CH_3CO_2H(aq) and NaOH(aq)
- Practical 5: Dilution and choice of indicators
- Practical 6: Determination of mass percentage of sodium carbonate in a mixture containing sodium carbonate and sodium chloride [Unfamiliar situation – Back titration]

Experiment	Technique	Understanding of
1	Weighing using electronic balance	Weigh accurately about
2	Microscale	Small is beautiful
3	Use of burette End point recognition of methyl orange indicator	Reading the burette
4	End point recognition of phenolphthalein indicator Cleaning of pipette / burette / conical flask	What type of solution is used to rinse the apparatus?
5	Use of volumetric flask and choice of indicators	Dilution
6	Expt 3 - Expt 5	-

Trial run with the use of google form Expt 1

QUESTIONS RESPONSES 31

Form description

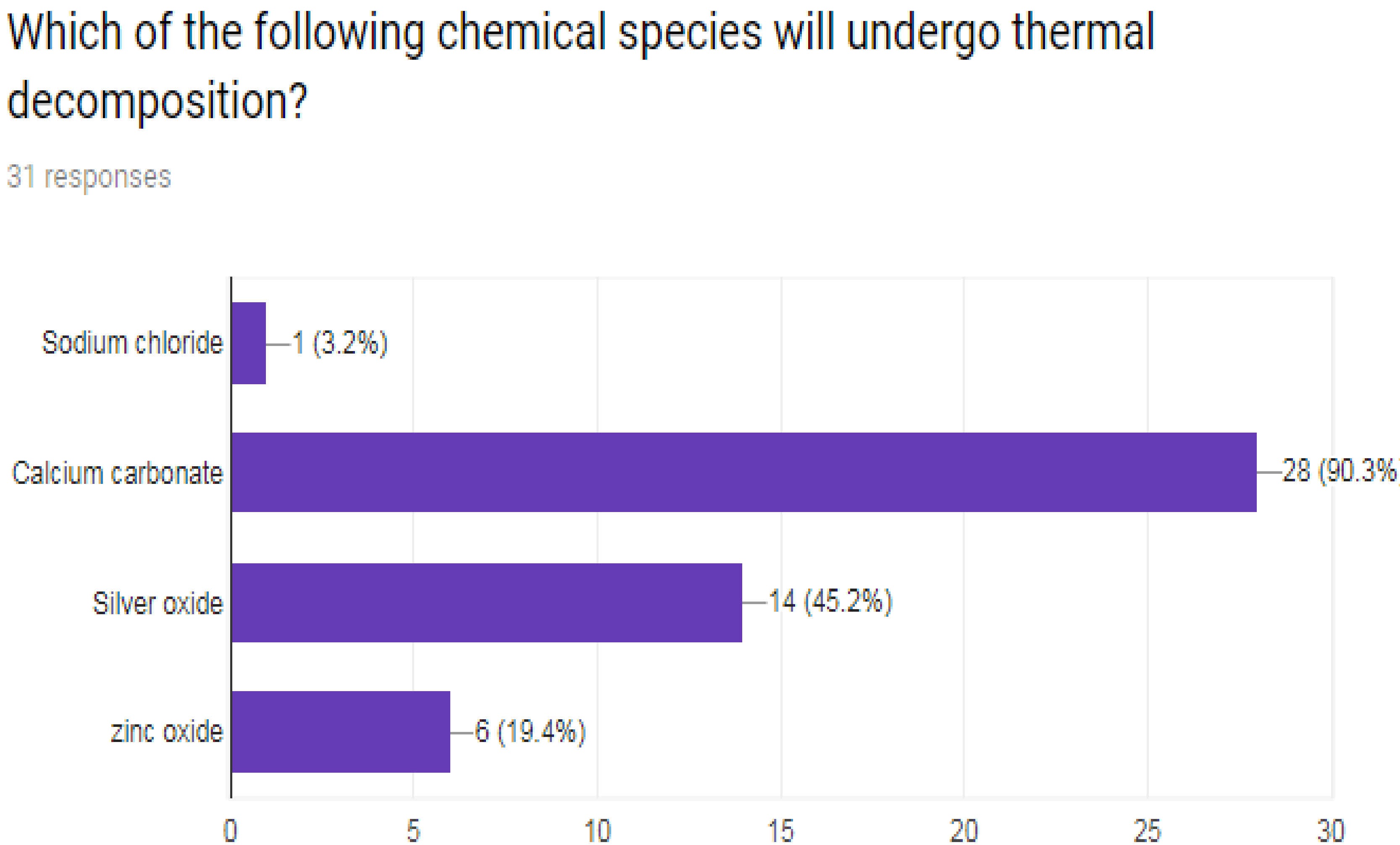
Which of the following chemical species will undergo thermal decomposition?

- [ ] Sodium chloride
- [ ] Calcium carbonate
- [ ] Silver oxide
- [ ] zinc oxide

Give the formula mass of the following four chemical species. (1) sodium hydrogencarbonate (2) sodium carbonate (3) sodium oxide (4) sodium hydroxide

Short answer text

Trial run with the use of google form Expt 1



Trial run with the use of google form Expt 1

There are 3 possible decomposition reactions when sodium hydrogencarbonate is heated. For each of the following possible reaction, write a chemical equation.

Description (optional)

1) sodium hydrogencarbonate(s) -> sodium hydroxide (s) + carbon dioxide (g) *

Short answer text

2) sodium hydrogencarbonate(s) -> sodium oxide (s) + carbon dioxide (g) + water (g)

Short answer text

3) sodium hydrogencarbonate(s) -> sodium carbonate(s) + carbon dioxide (g) * + water (l)

Short answer text

Relative atomic masses for calculations: Na: 23.0, H = 1.0, C = 12.0, O = 16.0

Trial run with the use of google form Expt 1

Calculate the amount of a 2.0 g sample of sodium hydrogencarbonate in mole. *

Short answer text

If you start with 2.0 g of sodium hydrogencarbonate, calculate the respective mass of residue according to the first chemical equations (i.e. Equation 1). *

Long answer text

If you start with 2.0 g of sodium hydrogencarbonate, calculate the respective mass of residue according to the second chemical equations (i.e. Equation 2). *

Long answer text

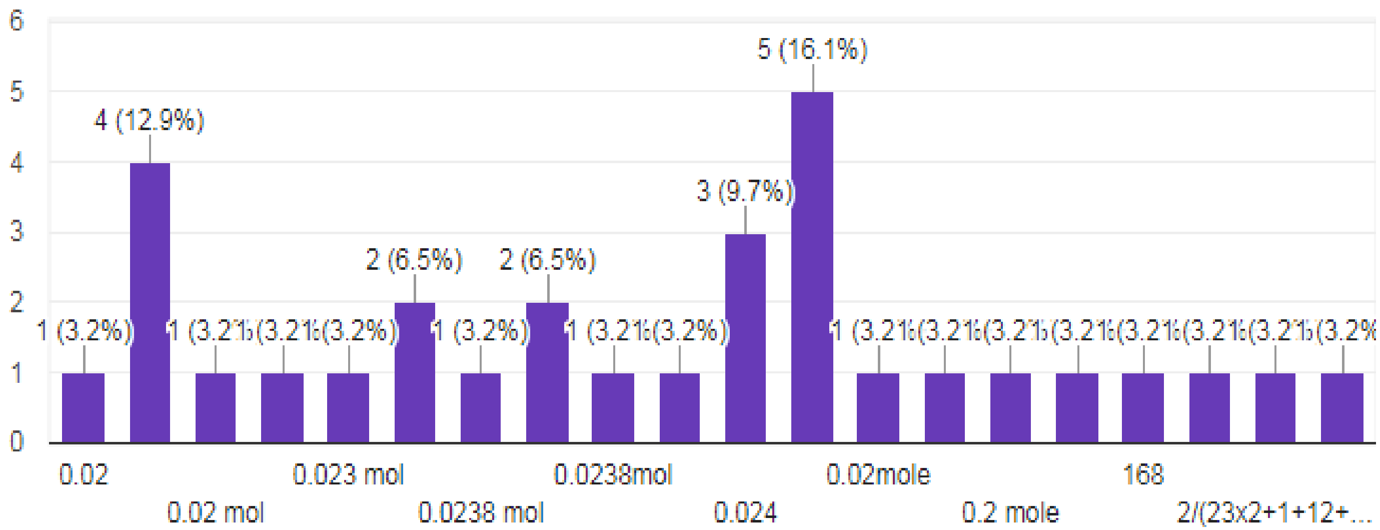
If you start with 2.0 g of sodium hydrogencarbonate, calculate the respective mass of residue according to the third chemical equations (i.e. Equation 3). *

Long answer text

Trial run with the use of google form
Expt 1

Calculate the amount of a 2.0 g sample of sodium hydrogencarbonate in mole.

31 responses



Trial run with the use of google form
Expt 1

The experimental set-up for the decomposition of sodium hydrogencarbonate is as follows. Suggest any safety measures that have to be taken. *

Long answer text

Heating of sodium hydrogencarbonate

Trial run with the use of google form Expt 6

1. In this experiment, assume you are asked to weigh a sample of about 1.00 g accurately. Which of the following weights are not accepted? *

- [ ] 1.50 g
- [ ] 1.02 g
- [ ] 1.0 g
- [ ] 0.99 g
- [ ] Other...

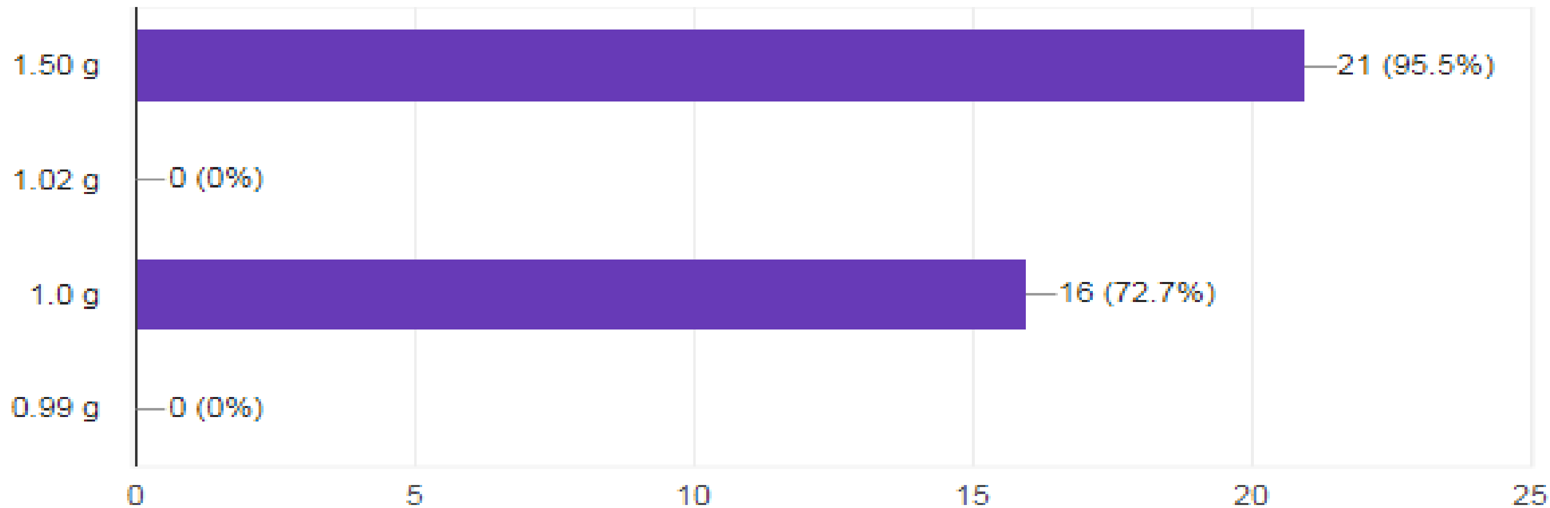
2. If the weighed sample is added to 10.00 ml 2 M hydrochloric acid, what is the total amount of hydrochloric acid used? *

Short answer text

Trial run with the use of google form Expt 6

1. In this experiment, assume you are asked to weigh a sample of about 1.00 g accurately. Which of the following weights are not accepted?

22 responses



Link up with games / tests

If you are asked to weigh a sample accurately about 3.50 g, which of the following masses can be considered as (an) appropriate mass(es)?

(1) 3.45 g (2) 3.5 g (3) 5.30 g

A. (1) only B. (2) only

C. (1) and (3) D. (2) and (3)

Which of the following chemical species will give a gas upon heating?

(1) Na_2CO_3 (2) $CaCO_3$ (3) Ag_2O

A. (1) and (2) B. (1) and (3)

C. (2) and (3) D. (1), (2), (3)

Which of the following chemical species are corrosive?

(1) $NaOH(s)$ (2) $Na_2O(s)$ (3) $H_2SO_4(l)$

A. (1) and (2) B. (1) and (3)

C. (2) and (3) D. (1), (2), (3)

Exemplars (Back Titration)

3. A impure sample of ammonium chloride was added to excess NaOH and heated strongly such that all the ammonia evolved will be absorbed by 100.00 cm^3 0.2 M H_2SO_4 which was in excess. All the contents were then made up to 250.00 cm^3 in an apparatus A. 25.00 cm^3 of the diluted solution in A was then taken and required a mean titre of 20.00 cm^3 of 0.05 M Na_2CO_3 for complete reaction.

(a) Name apparatus A. volumetric flask

(1 mark)

(b) Describe briefly how the student can take the 25.00 cm^3 of the diluted solution. Pour the solution into a beaker first, then use a pipette to take 25.00cm³ of the diluted solution.

(2 marks)

(c) If methyl orange indicator is used as the indicator, what is the colour change at the end point? red to orange

(1 mark)

(d) Two of the chemical equations involved are as follows:

$NH_4Cl + NaOH \rightarrow NaCl + NH_3 + H_2O$; $2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

Calculate the mass of ammonium chloride in the sample.

[Relative atomic masses: S = 32.0, N = 14.0, H = 1.0, Cl = 35.5, O = 16.0]

(4 marks)

$H_2SO_4(aq) + Na_2CO_3(aq) \rightarrow Na_2SO_4(aq) + H_2O(l) + CO_2(g)$

Na_2CO_3: 0.020 × 0.05
= 0.001 mol

H_2SO_4 = 0.001 mol

H_2SO_4 (acid) react with NH_3 = 0.1 × 0.2 − 0.001
= 0.019 mol

NH_3 = 0.019 × 2
= 0.038 mol

∴ NH_4Cl = 0.038 mol

mass of NH_4Cl: (14.0 + 1.0×4 + 35.5) × 0.038
= 2.033 g

Exemplars (back titration)

3. A impure sample of ammonium chloride was added to excess NaOH and heated strongly such that all the ammonia evolved will be absorbed by 100.00 cm^3 0.2 M H_2SO_4 which was in excess. All the contents were then made up to 250.00 cm^3 in an apparatus A. 25.00 cm^3 of the diluted solution in A was then taken and required a mean titre of 20.00 cm^3 of 0.05 M Na_2CO_3 for complete reaction.

(a) Name apparatus A.

volumetric flask

(1 mark)

(b) Describe briefly how the student can take the 25.00 cm^3 of the diluted solution.

Use a pipette to measure the volume transfer the ~~solution~~ for titration.

Transfer the solution to the beaker.

(2 marks)

(c) If methyl orange indicator is used as the indicator, what is the colour change at the end point?

from red to orange

(1 mark)

(d) Two of the chemical equations involved are as follows:

$NH_4Cl + NaOH \rightarrow NaCl + NH_3 + H_2O$; $2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

Calculate the mass of ammonium chloride in the sample.

[Relative atomic masses: S = 32.0, N = 14.0, H = 1.0, Cl = 35.5, O = 16.0]

(4 marks)

The no. of moles of H_2SO_4 reacted

$((100 \times 0.2) \div 1000 - (20 \times 0.05) \div 1000 \times 10)$

$= 0.01$

The no. of moles of NH_3 :

0.01×2

$= 0.02$ = the no. of moles of NH_4Cl

The mass of NH_4Cl :

$0.02 \times (14 + 4 + 35.5)$

$= 1.07$ g

= 10.1g

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Responses from students

F.4C Learning activity: Web-based pre-experimental assignment and practical activity

Please select the most appropriate answer. The choice here is not a choice between the right and the wrong.

* Required

I think the web-based pre-experimental assignments were easy to complete. *

	1	2	3	4	5	
totally disagree	○	○	○	○	○	totally agree

I think the web-based pre-experimental assignments were interesting. *

	1	2	3	4	5	
totally disagree	○	○	○	○	○	totally agree

I think the web-based pre-experimental assignments indicated what I did not understand in the related topic. *

	1	2	3	4	5	
totally disagree	○	○	○	○	○	totally agree

I think the web-based pre-experimental assignments enhanced my motivation to learn. *

I think the in-class discussion and the practical activity:

clarified my understanding in concepts of mole calculation. *

	1	2	3	4	5	
totally disagree	○	○	○	○	○	totally agree

were interesting. *

	1	2	3	4	5	
totally disagree	○	○	○	○	○	totally agree

enhanced my confidence in solving problems on mole calculations. *

	1	2	3	4	5	
totally disagree	○	○	○	○	○	totally agree

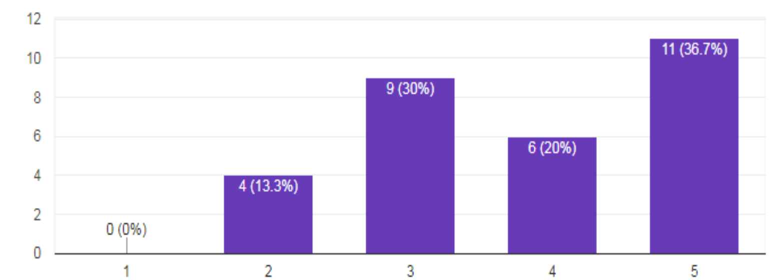
made me enjoy the lesson. *

	1	2	3	4	5	
totally disagree	○	○	○	○	○	totally agree

Responses from students

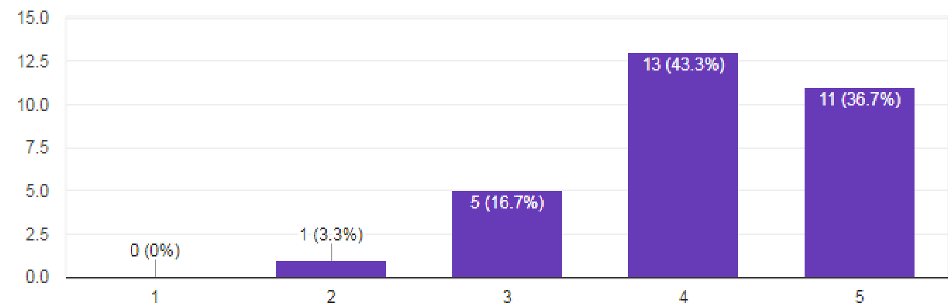
I think the web-based pre-experimental assignments were easy to complete.

30 responses



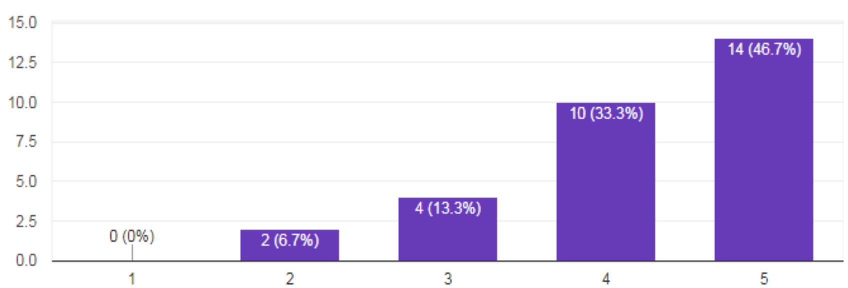
I think the web-based pre-experimental assignments were interesting.

30 responses



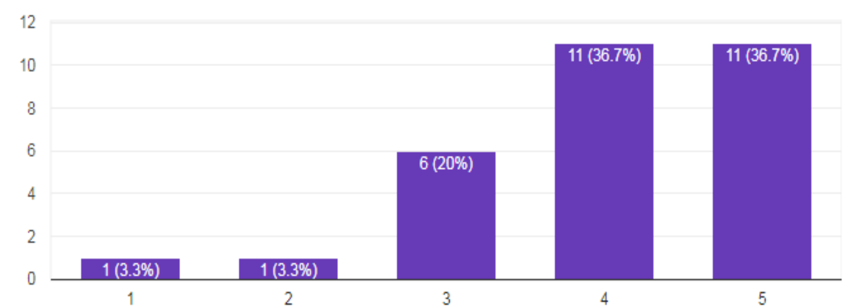
I think the web-based pre-experimental assignments indicated what I did not understand in the related topic.

30 responses



I think the web-based pre-experimental assignments enhanced my motivation to learn.

30 responses

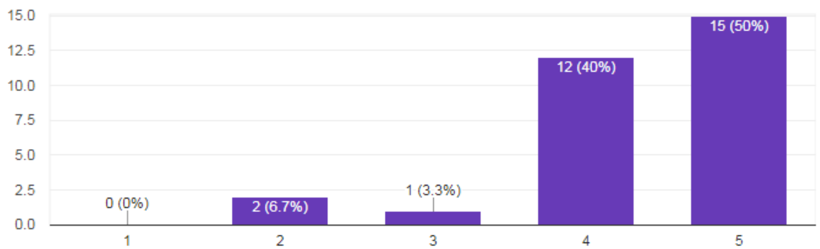


Responses from students

I think the in-class discussion and the practical activity:

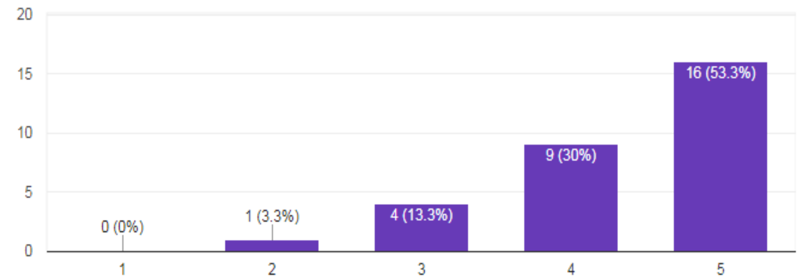
clarified my understanding in concepts of mole calculation.

30 responses



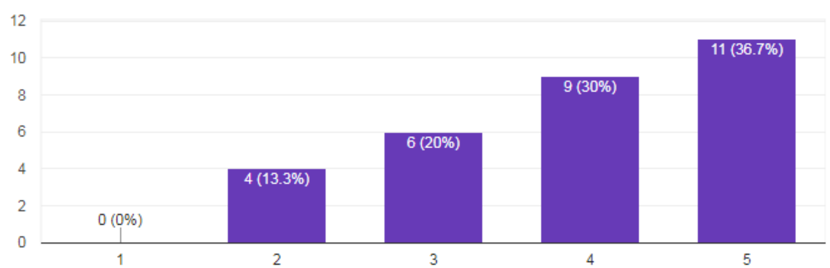
were interesting.

30 responses



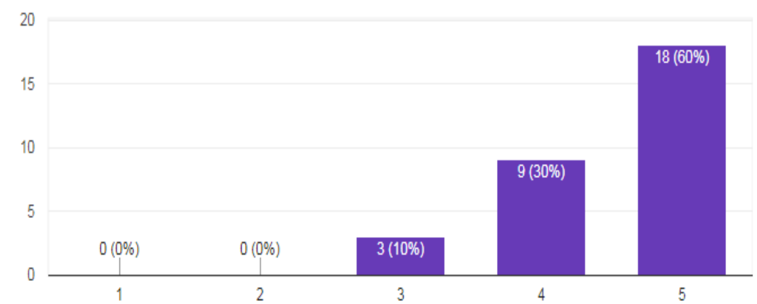
enhanced my confidence in solving problems on mole calculations.

30 responses



made me enjoy the lesson.

30 responses

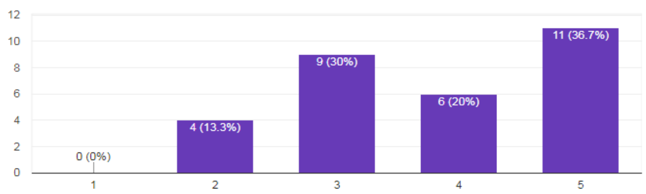


Responses from students

Comments about e-learning in Chemistry:

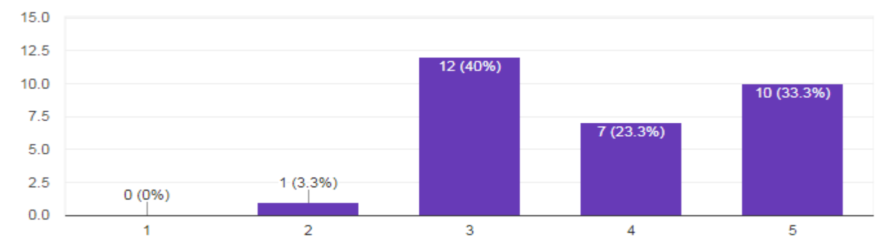
I wish there are more e-learning activities in Chemistry.

30 responses



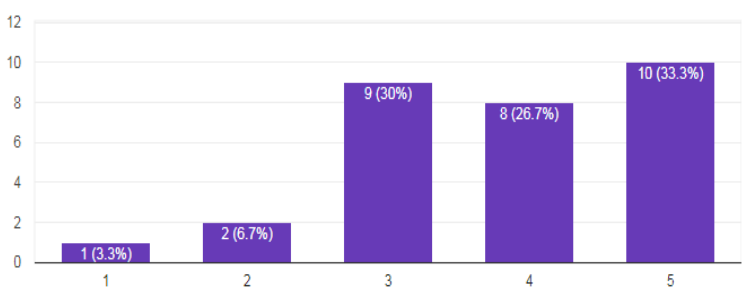
I think e-learning activities make learning chemistry more effective.

30 responses



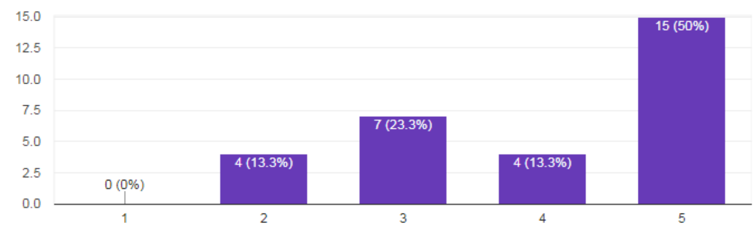
I am proficient in IT skills for completing e-learning tasks.

30 responses



I did not encounter any problem in accessing the Internet for completing the e-learning tasks.

30 responses



Other opinions:

Other opinions about this learning activity:

0 responses

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Other remarks

- Already joined the HKEdcity programme
  - Construct MC questions
  - https://www.hkedcity.net/questionbank/

- Use of plickers / Kahoot to collect immediate responses

Other remarks

	Know	Don't know
Know		
Don't know		

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