CHEMISTRY (CHM315115)

PART I – CRITERION 5

The performance in section of the examination was strong with the large majority of students scoring 20 marks or more out of 40, and a large proportion of students scoring more than 34 marks out of 40.

QUESTION 1

This entire question was generally well answered.

Part (a) Majority answered correctly. Most common error was oxidation state of +3 rather than -3 in part iv.

Part (b) In part i, the question asked for the conversion of the ‘nitrate ion’, but many used HNO₃. Although not incorrect, it created errors in balancing as students did not account for the H in HNO₃.

Part (b) ii was generally well answered, although some half equations were unbalanced and states were often left out.

Mistakes in parts i and ii were carried through to part iii, causing problems for a number of students. Balancing proved problematic. Also, students needed to be sure that they had an oxidation and a reduction equation in order to work out the net ionic equation.

QUESTION 2

Although most students knew the answer, communicating their understanding was done poorly. Students needed to focus on one species and its ability to act as an oxidiser or a reducer instead of focussing on separate species that contained the same element. Many tried to claim that strong oxidisers could be weak reducers. Good answers mentioned conjugate pairs. A number of students used hydrogen peroxide as their example, but this is an exception as it can act as an oxidiser and a reducer. It is an exception, and students need to focus on the general case.

QUESTION 3

Part (a) i was a straight-forward question but many students identified the half-cell rather than the CATHODE (electrode) - (D).

Part (a) ii was misunderstood by a number of students. The expected answer needed reduction of D₃⁺ (transfer of electrons from electrode to D₃⁺), not just transfer of electrons from anode to cathode. Specific reference to the electrochemical cell in the question was required for full marks.

Part (b) was answered well by most candidates. Needed to be sure to focus on the relationship between the movement of ions and electrons.

Part (c) was answered well.

For full marks on Part (d) evidence of working was expected. Voltage needed to correspond to something on ECS table. Many did well. Error carried forward was a common occurrence.
QUESTION 4

Part (a) was answered correctly by the majority of candidates. Most common error was answers did not have direction of ion flow as requested, but instead had direction of electron flow.

Part (b) i. A number of students answered for each pair of electrodes, rather than just the carbon electrode pair. Students would have benefited from reading the entire question first. Students also need to be careful that they get cathode and anode around the right way. An alarming number of students contended that solid sodium would form in an aqueous solution!

Part (b) ii. Care needs to be taken to say that dilution results in a decrease in concentration not in number of moles. Reference to comparative reduction strength of the species present was also needed for full marks.

Part (c) i. This question was well answered. It was evident that a large number of students are familiar with the blue colour of Cu^{2+} ions in solution. Part (c) ii was difficult for many students. A large variety of incorrect answers were provided. Students needed to say how time would change products, with specific reference to the ECS.

QUESTION 5

Part (a) should have been a straight forward but many students were not focused on what the question was asking. Students did not always compare with hydrogen gas, or make reference to metal X. The question asks for reduction strength not oxidation strength. Need to read the question and address the question.

Part (b) was mostly well answered. The question did not ask candidates to guess the identity of metals X, Y and Z, so students should not try to do so. Many did.

Part (c) was generally well done by students who had correctly answered the previous two parts. There was scope for error carried forward in this question.

Part (d) was done surprisingly well given that many students did not show a clear ranking in part (a). It suggests that students struggle with explaining their understanding. The question asked for ‘order of decreasing reducing strength’, but students often gave answers in the reverse order. Historically, this misunderstanding has been a common one. Students should take care.

QUESTION 6

The shipping container question seemed to be aimed at the container being used as a shed in a yard as opposed to a buried metal structure. Some students seemed to be anticipating the latter. In Part (a) students needed to show a circuit complete with an anode and a cathode, There were many drawings of ships. Many students thought protection with an impressed current also requires a sacrificial anode.

Part (b) was not answered well. Few students received full marks. Students needed to calculate the EMF of the spontaneous reaction and compare that to the application of an EMF of 1.25 V to receive full marks.

PART 2 - CRITERION 6

This section of the exam should have been straight-forward to pass, but proved difficult to achieve very high marks in. Many students lost marks for providing generic explanations that were not specific to the question.

QUESTION 7

Part (a) was generally well done. Full marks were awarded for an endothermic curve and fully labelled diagrams. Part (b). Many students misinterpreted the question, and a large number of students got the answer back to front. Students often referred to the general concept of K_c rather than the specific value given in the question.
Part (c) i. Most students correctly identified $K_c$ as the variable that changes, but did not discuss how (i.e. that the value of $K_c$ increased due to the FWD/endothermic reaction being favoured, according to LCP).

Part (c) ii. This was generally well done. Most students were awarded full marks for this question.

Part (d). Generally well done. Common mistakes included $6 \times (H-H)$ bond energy and simple calculation errors. The most common errors were failure to rearrange the bond energies and $\Delta H$ to find the unknown, or writing an invalid expression in the first place. Many students received 3 marks out of 4 for this question.

**QUESTION 8**

Part (a). Not many students were awarded full marks for this question. The most common mistake was failure to answer both parts of the question; specifically the second part (i.e. system had reached equilibrium). Most students only provided an explanation for the initial colour change. An alarming number of students suggested that the colour change was due to dilution of the brown gas by the colourless gas, hence light brown! No reference to equilibrium.

Part (b). The majority of students made admirable attempts at this question; however, few were awarded full marks for this question. Many students failed to answer the question (i.e. has the volume been increased or decreased?), and a large number of students incorrectly suggested that a decrease in volume causes a decrease in pressure.

Part (c) was not a difficult question but it was generally poorly answered. It was clear that students had difficulty interpreting the information that was provided. Every conceivable mistake was observed, but the most common were not converting n(mole) to concentration, not using an I.C.E. diagram and failure to recognising the 2:1 ratio, incorrect $K_c$ expressions and simply misinterpreting the data provided (many students thought that there was $0.710 \text{ mol of NO}_2$).

**QUESTION 9**

Part (a). A straightforward question that was not well answered. Full marks awarded for correct curve shape and horizontal section at 4 min. Students should use a ruler for straight sections of graphs.

Part (b). Many answers were accepted providing correct units were given. Half marks if students used 5 min rather than 4 min.

Part (c). Generally well-answered. Full marks required mention of increased SA causing an increased NUMBER of collisions, hence increased EFFECTIVE collisions hence increased RATE. Many students neglected to mention effective collisions.

**QUESTION 10**

Very few candidates were awarded any marks for this question. Most failed to recognise that the question was about conflicting driving forces (max entropy, min enthalpy). Many students wrote very long answers that missed the point of the question. Many students thought that because Equation A was exothermic that it would go to completion. A number of students referred to bond breaking and redox reactions.

**QUESTION 11**

Part (a). Well answered; however, some students were clearly confused as to how a dissociation equation can demonstrate strength/weakness of an acid. As such, students tried many creative ways including using equilibrium arrows of different lengths.

Part (b). Typically, students either could or could not answer this question. Marks were deducted for failure to justify disappearance of “$x$”, which is especially important given that the $K_a$ is $1.8 \times 10^{-4}$. Many students failed to calculate $[\text{OH}^-]$, incorrectly assuming it was equal to $[\text{H}^+]$ or absent altogether “because it’s an acid”.

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Part (c) was poorly answered. Many students contradicted themselves (e.g. it definitely won’t, but it might). Too many students referred to a pH of 7 as neutral rather than the discussing the relative concentrations of H⁺ vs OH⁻.

QUESTION 12

Part (a) was surprisingly poorly done. Most candidates were able to draw a right-hand shift; however, paid little regard to the size of the area of the curve. Some students explicitly pointed out that the areas should be equal.

Part (b) was well attempted, but not many students received full marks. The most common error was the failure to mention the two-fold effect of increased temp (i.e. increased frequency and increased energy of collisions leading to increased effective collisions, therefore increased rate).

*NOTE:* very few students referred to the diagram; however, this was not penalised.

QUESTION 13

Part (a). Well done. Most students recognised that increase in temperature was responsible for the change, but for full marks relating the temperature change to enthalpy change of reaction and changing concentration of reactants and products was needed.

Part (b). Most students thought there was no change and simply stated that it was still at equilibrium. Full marks were given for suggesting addition of catalyst and/or inert gas and the fact there was no effect on the equilibrium position/concentration of species present.

Part (c). Generally well answered, although full marks were reserved for students who denoted proportion of change with pronumerals (e.g. x, 2x, 3x). The shape of curves was generally correct, plateauing at t4. Students need to avoid having curve return to original position/concentration.

PART 3 - CRITERION 7

This section was generally well done. Questions requiring explanations proved difficult for some candidates. Communication is a common problem for students. There were some unfamiliar abbreviations/acronyms employed by students such as IMF, Fe (not in reference to iron), KTG and MTG. More common abbreviations such as e⁻ (for electrons), p⁺ (for protons), I.E. (for ionisation energy) and Eₖ (for kinetic energy) are widely recognised and, as such, appropriate.

QUESTION 14

Part (a). Students need to read the question – answer relating to electronegativity, not radius. More detail needed rather than “want to become stable” or “7 valence electrons for chlorine”. Refer to nuclear charge, shielding and attraction of electrons. Avoid anthropomorphic terms like “want”. Elements of the periodic table do not “want” anything.

Part (b). This must be ions not atoms. Electron configurations were needed, not element symbols. The quantum model accepted – full marks were not given for answers referring to the Bohr model. Students demonstrated a poor understanding of the difference between cation and anion electron configurations.

Part (c) This must be also refer to an ion, not an atom. Many students picked Na⁺ as they didn’t consider the drop in electron shell numbers. Cl⁻ was common too as students didn’t consider the proton to electron ratio.

QUESTION 15

Part (a). Most students seemed to know the answer, but failed to explain “why”. Answers generally needed a greater emphasis on the increased nuclear charge.
Part (b) Reference to the gaseous state was required for full marks in this question. The most common error was providing the reverse equation.

Part (c). In this question, the 1st I.E. was explained well for Li; however, the 2nd I.E. was not as clearly expressed — many students just compared to the same number of electrons as He and failed to reference the increased nuclear charge. 0 and 3rd I.E were not required in the graph or explanation.

QUESTION 16

Part (a). Stating “noble gas” is not sufficient. Reference to reactivity was required.

Part (b). Not well answered. More reference to energy shells is needed. The question is about absorption not emission. Students need to remember that electrons are excited, not removed, in this question.

Part (c). Not well answered. Many students missed the point of the question. There was some confusion between groups and periods in explanations. Students need to consider the time period (1869) of the question. No electron configurations were known, nor were the atomic numbers. Students were not penalised for this.

QUESTION 17

Part (a). Lots of students considered this as a strong oxidising agent, rather than mild. Part marks were given for carboxylic acid. No marks were given for an alcohol as product.

Part (b). Generally well answered.

Part (c). The catalyst (H₂SO₄) was often forgotten or placed as a reagent rather than above the reaction arrow. Many students neglected to include water as a product in this dehydration reaction. No marks for ethane as a product.

QUESTION 18

Part (a). Poorly done. Students seemed to find it difficult to interpret the structural formula from the information provided. Part marks were given if the product only had the carboxylic acid portion included.

Part (b). Many students forgot to include water as a reagent and the catalyst above the reaction arrow.

Part (c). If students are going to refer to “isomer I” they should number the isomers in the question initially. Students should read the question and refer to the least soluble, rather than most. Marks were given for both polarity explanations and H-bonding explanations.

Part (d). Many students picked the carboxylic acid – part marks were given if this was well explained. The peak at 3400 cm⁻¹ is for a non-carboxylic acid –OH functional group.

QUESTION 19

Part (a). Well done. Naming for A – “hydroxyl” notation was not accepted. ‘dí’ was often missing or in the wrong spot. Naming of B – position number was often missing.

Part (b). Very poorly done. Many students assumed it as an addition polymer despite it saying condensation in the question.

Part (c). Poorly done. Some students didn’t read “compound D” in the question and drew more condensation polymers.
Part (d). Some students didn’t make the connection that it was continued from the previous page (reinforces the importance to read the entire question before starting).

(i) Questions states that students need to identify A, B, C, D rather than just the name of the functional group.

(ii) Students need to explain rather than just re-stating the information from the table - “last one left” isn’t satisfactory “reasoning”. Many students misunderstood the Br2 test results.

QUESTION 20

Part (a). Overall this was poorly explained by students. The acronym IMF was used often and there was a perception that ideal gases are all unreactive. Stating that these gases have no mass or volume is not correct. Students should be using “negligible” mass or volume of particles.

Part (b). Students should address the collisions with the vessel wall, particularly considering collisions per unit area and the Eo of the gas particles when referring to pressure.

Part (c). As stated in the question, a mathematical relationship was needed. An equation was adequate. Many students forgot to address the “comment on the unit(s)” part of the question. PV=nRT was commonly used but was not well explained regarding V, n or R being constant.

PART 4 - CRITERION 8

Prior to discussing issues specific to each question, it is worth mentioning that a large number of calculation errors and skill errors were evident in many of the questions in this section. This could be due to unfamiliarity with standard scientific calculators after previously using Classpad calculators in other subjects such as Maths Methods 3/4 or General Maths 3. Errors included truncating values, misreading information from their calculator screens, juxtaposing digits, misreading data from the question (e.g. 367 was replaced with 376, 186 was replaced with 180, etc.), incorrectly entering values presented in scientific notation and misinterpreting calculator answers, as just a few examples. Marks were deducted for any of the errors mentioned above. This should serve as a warning that students need to be careful with their calculator work and not assume that markers will be lenient with “small errors”.

It was also concerning to note that students struggled with stoichiometric ratios often incorrectly applying the equation ratios.

QUESTION 2.1

Part (a) was attempted quite successfully by the majority of students. The question requested that students “show that the concentration of phosphoric acid is about 0.15 M.” This means that students were given a rough idea of what the answer should have been and also the number of significant figures required. If, for some reason, students were not able to successfully calculate the answer, they were instructed on the inside cover of the exam booklet that “students should use the value given by the examiner in subsequent questions when required”.

On the other hand, if students were successful in calculating the true answer, 0.14 M, they were instructed in the following question to use the “concentration calculated in part (a)”.

These points were overlooked by many students with a large proportion of students using an incorrect concentration. Marks were deducted for failing to follow instructions.

Part (b). As mentioned above, the concentration of phosphoric acid to be used in this calculation was either 0.14 M if successful in part (a), or 0.15 M if unsuccessful in part (a). A large number of students made the error of calculating the number of moles of diphosphorus pentoxide by using the volume and concentration of phosphoric acid. The correct number of moles was a quarter of value of that of the phosphoric acid.
The follow up question required calculating the amount of heat evolved when \(2.00 \times 10^4\) L of phosphoric acid was produced. The value required was an absolute value. It was possible to calculate this by using the appropriate number of moles of either the diphosphorus pentoxide or the phosphoric acid. This meant that students needed to be aware that the quoted \(\Delta H\) value of 177 kJ was valid for the number of moles of diphosphorus pentoxide. If the number of moles of phosphoric acid were being used, the \(\Delta H\) value of 177 kJ needed to be divided by four. This was a common source of errors.

**QUESTION 22**

This question was poorly attempted by a large number of students. Many students seemed to think that a reaction was occurring and that the final concentration of chloride ions was dependent on the number that remained unreacted. Full marks were not possible for this question if students incorrectly mentioned “limiting reactants” and performed calculations based on this premise. The correct approach was to separately calculate the number of moles of chloride ions dissociated from the respective solutes (1:1 in the case of NaCl and 1:2 in the case of BaCl₂) and then combine these values by using the appropriate formula. Marks were deducted for incorrect number of significant figures as demanded in the question (NOTE: incorrect number of sig figs are generally overlooked, but not when specified in the question).

**QUESTION 23**

A poorly understood question with many students obtaining only part marks. There were a number of approaches possible for this question, but the main error observed was students neglecting the critical step of multiplying the number of moles of aluminium oxide by 2 to arrive at the necessary number of moles of aluminium present in the given sample. Often, half of the correct answer of 1.687% was obtained, mainly due to the aforementioned omission.

**QUESTION 24**

Part (a). This was another question where students were given a rough approximation to the answer required: “show that……… the heat of reaction of…… was about +111 kJmol⁻¹”.

This means that this value should have been used in the follow up question if students were unable to calculate the correct value. On the other hand, the correct value of approximately +109 kJmol⁻¹ should have been used if students were successful.

Some errors noted in this question included the incorrect substitution of 6.25 grams into the formula \(E = m \times c \times \Delta T\) (instead of the correct value of 50 grams), the incorrect use of units, incorrectly calculating the molar mass of copper sulfate pentahydrate and incorrect manipulation of the formula \(\Delta H = \frac{E}{n}\)

Some students used the information regarding the temperature drop of 1.30°C as a negative value in the formula \(E = m \times c \times \Delta T\) which then created errors in subsequent steps.

Some interesting calculations were attempted by students in an attempt to arrive at the necessary +111 kJmol⁻¹. These were not always legitimate, but often creative!

**QUESTION 25**

Part (a) was very poorly attempted. Students seemed unable to interpret what was required. Very few students were able to negotiate the steps required to arrive at the correct answer of \(2.46 \times 10^4\) mol L⁻¹.

Students were unable to recognise the prefix \(\mu\) (micro) as \(10^6\) and this is a lamentable error as it is available on the information sheet. Misunderstanding of scientific notation was very apparent in this question.

Part (b). This question was also attempted very poorly by a majority of students. The main cause of concern for students was the mathematics required to demonstrate a percentage increase. Students often attempted to
compare the wrong values in the calculations. One successful approach involved calculating the concentrations of hydrogen ions for the two situations, historically and now, and determining that \( \frac{8.31 \times 10^{-9}}{6.3 \times 10^{-9}} \) expressed as a % reflected an approximate 32% increase. (132% = 32% increase).

Students who attempted similar calculations with \( pH \) values quickly became unstuck since they were attempting to show percentage increments on a logarithmic scale.

For full marks, students were required to state their conclusion (accept or reject the assertion).

**QUESTION 26**

This question was attempted quite successfully by the majority of students. Some common errors, though, were:

- Incorrectly converting 367 milliamperes to amperes for use in the relevant formula.
- Assuming that the number of moles of electrons was equivalent to the number of moles of the trivalent metal (there was, in fact, a need to divide by three).
- Incorrect transposition of the expression \( n = \frac{m}{M} \)
- Attempting to identify the unknown as all sorts of elements which were not trivalent as suggested in the question (which should have served as a big clue that an error had occurred). In some cases non-metal elements were suggested when clearly the question stated a metal was the unknown.

**QUESTION 27**

This question highlighted a real weakness in a large number of students. Many students were not able to deal with the algebraic manipulations required to solve for the unknown concentration of hydrogen when its value was in the denominator of the expression for the equilibrium of the reaction given.

Many students were also mistaken into believing that this it was an “I.C.E. type question” and failed to recognise that the data given in the question actually referred to the equilibrium concentrations of the species concerned. That meant that this was a “substitute and solve” type question. A large proportion of students left the question incomplete, failing to calculate the number of moles of hydrogen required in the last step.

**QUESTION 28**

Part (a). This question involved appreciating that the relationship \( n \sim V \) applied in this case. Therefore suitable calculations were able to be performed using volumes. Students also needed to determine the volumes of the products by using the appropriate stoichiometric ratios to come up with required answer of \( \Delta V = 4L \). NO credit was given for arriving at the answer of 4L by simply subtracting 16 from 20.

Part (b). Students were required to calculate the number of moles of reactants and determine which was the limiting reactant. This value would then be used to determine the theoretical maximum amount of nitric oxide possible. This was then compared with the actual amount yielded to arrive at the answer. Some common errors were:

- Attempting to convert all the information into % composition
- Failure to identify the limiting reactant (maximum of half marks given in this instance).
- Confusion with the fact that three different mass amounts were given, with often all three converted into moles with no further follow up.
QUESTION 29

Most students were able to obtain at least some marks for this question.

Students were required to determine the number of moles of zinc reacted from which the number of moles of hydrogen gas evolved could be determined (1:1 ratio). Students then needed to calculate the volume of hydrogen gas collected by using the general gas equation and the stated data. Some errors that were noted:

- Incorrectly converting 755 mmHg into the corresponding kPa value if desired.
- Use of the incorrect gas constant.
- Incorrect use of stoichiometric ratios in determining the amount of hydrogen gas evolved.
- Failure to convert 20°C into Kelvin
- Not being sure how to convert the volume obtained into the amount represented by “one measure”.

SOLUTIONS
**Criteron 6.**

(1) Boiling point: A temperature increase causes this system to adjust in favor of the cooler component. This reaction is at equilibrium: 

H₂O(l) → H₂O(g)

- Reaction is favored at higher temperatures.
- Reaction is favored at lower temperatures.
- Reaction proceeds to completion.

(2) Catalyst addition: Catalyst aids in increased reaction rates. It does not change the reaction itself.

- Catalyst increases the rate of reaction.
- Catalyst does not change the equilibrium position.

- Catalyst increases the rate of reaction.

- Catalyst increases the rate of reaction.

**Criteron 7.**

(1) Electron configuration: A review of electron configurations shows that... 

- Electron configuration of X: [Ar] 3d⁶ 4s⁵
- Electron configuration of Y: [Ar] 3d⁷
- Electron configuration of Z: [Ar] 3d⁸

(2) The lanthanide series: This group of elements... 

- The lanthanide series exhibits a... 
- The lanthanide series exhibits a... 
- The lanthanide series exhibits a... 

- The lanthanide series exhibits a... 

(3) The atomic radius: As we move down the periodic table, the atomic radius increases. 

- The atomic radius of X is larger than... 
- The atomic radius of Y is smaller than... 
- The atomic radius of Z is smaller than... 

- The atomic radius of X is larger than... 

(4) Bonding energy: CO₂ is a Lewis acid. 

- Bonding energy in CO₂ is 805 kcal/mol. 

- Bonding energy in CO₂ is 785 kcal/mol. 

- Bonding energy in CO₂ is 805 kcal/mol. 

(5) In the presence of a catalyst, the reaction rate... 

- The reaction rate increases exponentially. 

- The reaction rate increases exponentially. 

- The reaction rate increases exponentially. 

- The reaction rate increases exponentially. 

- The reaction rate increases exponentially. 

**Criteron 8.**

(1) A solution at 25°C is at equilibrium. 

- A solution at 25°C is at equilibrium. 

- A solution at 25°C is at equilibrium. 

- A solution at 25°C is at equilibrium. 

- A solution at 25°C is at equilibrium. 

(2) At a certain temperature, the reaction is at equilibrium. 

- At a certain temperature, the reaction is at equilibrium. 

- At a certain temperature, the reaction is at equilibrium. 

- At a certain temperature, the reaction is at equilibrium. 

- At a certain temperature, the reaction is at equilibrium. 

- At a certain temperature, the reaction is at equilibrium. 

(3) The enthalpy change: 

- The enthalpy change is... 

- The enthalpy change is... 

- The enthalpy change is... 

- The enthalpy change is... 

- The enthalpy change is... 

- The enthalpy change is... 

(4) The entropy change: 

- The entropy change is... 

- The entropy change is... 

- The entropy change is... 

- The entropy change is... 

- The entropy change is... 

- The entropy change is... 

(5) The free energy change: 

- The free energy change is... 

- The free energy change is... 

- The free energy change is... 

- The free energy change is... 

- The free energy change is... 

- The free energy change is... 

**Criteron 9.**

(1) Reactant: A, B, C, D. 

- Reactant A is a gas at 25°C. 

- Reactant B is a liquid at 25°C. 

- Reactant C is a solid at 25°C. 

- Reactant D is a liquid at 25°C. 

(2) Bonding energy: H₂O(l) → H₂O(g)

- Bonding energy in H₂O(l) is 80 kcal/mol. 

- Bonding energy in H₂O(g) is 80 kcal/mol. 

- Bonding energy in H₂O(l) is 80 kcal/mol. 

- Bonding energy in H₂O(g) is 80 kcal/mol. 

- Bonding energy in H₂O(l) is 80 kcal/mol. 

- Bonding energy in H₂O(g) is 80 kcal/mol. 

(3) The enthalpy change: 

- The enthalpy change is... 

- The enthalpy change is... 

- The enthalpy change is... 

- The enthalpy change is... 

- The enthalpy change is... 

- The enthalpy change is... 

(4) The entropy change: 

- The entropy change is... 

- The entropy change is... 

- The entropy change is... 

- The entropy change is... 

- The entropy change is... 

- The entropy change is... 

(5) The free energy change: 

- The free energy change is... 

- The free energy change is... 

- The free energy change is... 

- The free energy change is... 

- The free energy change is... 

- The free energy change is...
\[ n(Ca(OH)_2) = \frac{0.05 \times 0.20}{0.088} = 0.13 \text{ mol} \]

\[ n(H_3PO_4) = \frac{0.1 \times 0.02}{0.004} = 0.5 \text{ mol} \]

\[ n(H_2SO_4) = \frac{0.1 \times 0.01}{0.02} = 0.05 \text{ mol} \]

Total: \( n(Ca(OH)_2) = 0.13 \text{ mol} \)

\[ c(\text{Ca(OH)}_2) = \frac{0.13}{0.01} = 0.13 \text{ mol/L} \]

\[ c(H_3PO_4) = \frac{0.5}{0.01} = 50 \text{ mol/L} \]

\[ c(H_2SO_4) = \frac{0.05}{0.01} = 5 \text{ mol/L} \]

\[ V(\text{H}_2\text{SO}_4) = 0.05 \text{ L} \]

\[ M(\text{H}_2\text{SO}_4) = 0.05 \times 0.02 = 0.001 \text{ mol} \]

\[ \text{Volume of } H_2SO_4 = 0.001 \text{ L} \]

\[ n(\text{H}_2\text{SO}_4) = 0.001 \text{ mol} \]

\[ n(\text{H}_2\text{SO}_4) = \frac{0.01}{0.02} = 0.005 \text{ mol/L} \]

\[ n(H_3PO_4) = \frac{0.05}{0.01} = 5 \text{ mol/L} \]

\[ V(H_3PO_4) = 0.05 \text{ L} \]

\[ M(H_3PO_4) = 0.05 \times 0.02 = 0.001 \text{ mol} \]

\[ n(H_3PO_4) = 0.001 \text{ mol} \]

\[ n(Ca(OH)_2) = \frac{0.13}{0.01} = 0.13 \text{ mol/L} \]

\[ c(\text{Ca(OH)}_2) = \frac{0.13}{0.01} = 0.13 \text{ mol/L} \]

\[ c(H_3PO_4) = \frac{0.5}{0.01} = 50 \text{ mol/L} \]

\[ c(H_2SO_4) = \frac{0.05}{0.01} = 5 \text{ mol/L} \]