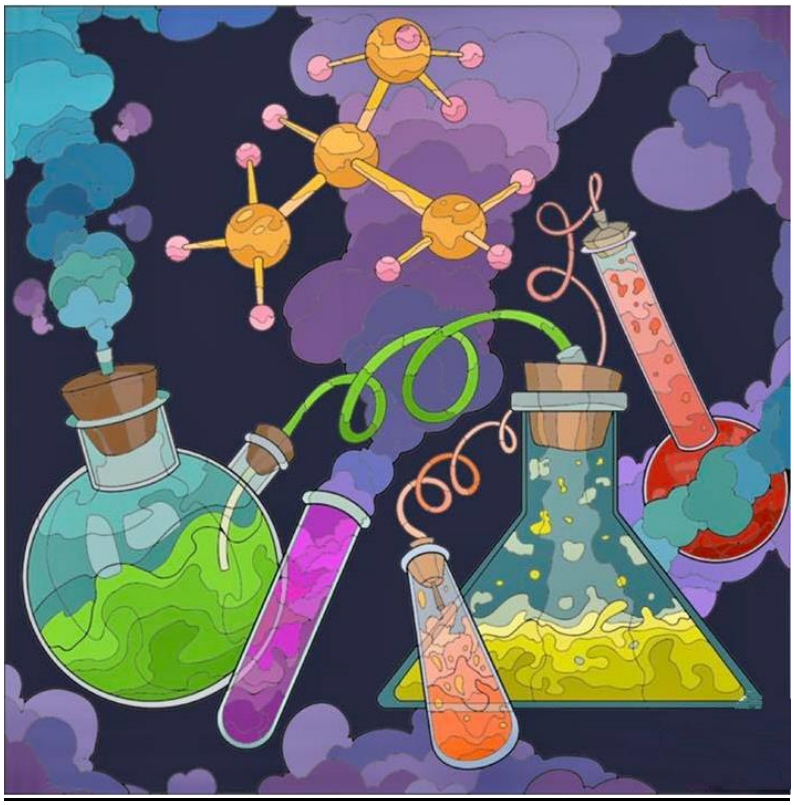
2018 SINGAPORE-CAMBRIDGE A LEVEL H2 CHEMISTRY P1 SUGGESTED ANSWER KEY (9729)

Written and Prepared by Mr Mitch Peh



Preface

Dear JC students in Singapore,
Hope you will find this A Level examination solution set useful for your revision.

The answers and comments to this solution set are personally crafted and written by Mr Mitch Peh, an experienced former MOE JC lecturer and tutor in Singapore. Currently, Mr Peh is a full time A Level private tutor, specialising in the teaching of A Level subjects: Physics, Chemistry, Mathematics and Economics at both H1 and H2 Levels. You can find the A Level solutions for the other subjects under the various subject tabs at www.jcpcme.com.

Mr Peh has a proven track record in helping his students achieve success for the A Levels and internal school examinations including promos, advancement tests to JC2, block tests, mid years and prelims. Most of Mr Peh's students achieve "A's and 'B's grades for the A Level examinations. During his stint teaching at St Andrew's Junior College, Mr Peh has helped his classes achieve 100% promotion to JC2 on multiple occasions, attain close to 100% "A"s for H1 Project Work, clinch accolades like "Most Improved Class Award" and "Best Performing Class of the Cohort" for many of the internal school examinations. Mr Peh also has former students who subsequently went on to pursue H3 subjects and enroll in prestigious university courses like Dentistry, Medicine and Law.

If you are interested to be coached by Mr Peh for your preparations towards the A Levels, these are 3 more reasons why you should join Mr Peh's classes:

1. **Lessons can be fully customised to your needs**
- You have the autonomy to decide the subject(s), content and pace that you want to cover for each lesson, out of any of the 4 subjects: Physics, Chemistry, Mathematics or Economics.
- Mr Peh will help to analyse your weaknesses in each individual subject and provide personalised feedback and suggestions for improvement.

2. **Answers to your questions can be addressed outside of the classroom**
- If you face any difficulty or challenge doing any of your tutorial questions, simply take a screenshot with your phone and send it to Mr Peh via Whatsapp. Mr Peh will answer your questions in the earliest possible time when he is available.

3. **You only pay the price of 1 subject but enjoy premium coverage for all 4 subjects**.
- Mr Peh provides resources for all 4 subjects including summarised notes, compiled topical questions sourced from past year school prelim examinations, Practical guides for Chemistry & Physics, examination checklists, mock papers etc.
- This is probably the only tuition service in Singapore which allows you to enjoy such extensive coverage and benefits.

Note that Mr Peh only takes in a limited number of students each year. You can find his lesson slots available under "Tuition Services" tab at www.jcpcme.com. For any further enquiries, you can directly whatsapp him at 9651 7737.

For the solution set below, if you find any discrepancies or you have any feedback or comments, please kindly direct them to Mr Peh through Whatsapp at 9651 7737.

The question paper has been omitted due to copyright reasons.

Analysis of 2018 A Level H2 Chemistry P1

- Overall, this should be a manageable paper for majority of students testing on many basic concepts especially for Inorganic Chemistry (Two-thirds of the paper).
- Some of these basic concepts tested in Inorganic Chemistry include:
  - Q1: Factors affecting deflection of particles between electric plates
  - Q2: Chemical bonding in $AlCl_3$ and Al_2Cl_6
  - Q3: Polar and non-polar molecules
  - Q4: Effect of nuclear charge on enthalpy change for removal of electron
  - Q5: Definition of atomic mass
  - Q6: Factors affecting atomic radius (Nuclear charge and number of electron quantum shells)
  - Q7: Calculating partial pressure
  - Q8: Definitions of the various enthalpy changes
  - Q9: Calculating enthalpy change with the use of energy cycle
  - Q10: Calculation involving oxidation number and redox reaction
  - Q11: Interpreting rate equation
  - Q12: Interpreting rate against concentration graph involving enzyme and substrate
  - Q13: Factor affecting acidity (Polarising ability of metal cation)
  - Q14: pH of water and relationship between $[H^+]$ and $[OH^-]$ when temperature increases
  - Q15: Constituents of buffer solution
  - Q17: Analysing reactions and deducing observations in Electrochemistry
  - Q18: Complex ions and their corresponding appearance
  - Q19: Identifying ligand exchange reaction
  - Q20: Density of transition metal compared to s block element
- For Organic Chemistry, this paper requires you to be familiar with analysing skeletal structures, know the interconnections between the topics.
  - Q24: Multiple roles that NaOH play, including acid-base reaction and hydrolysis of ester
  - Q27: Functional Groups that the different reducing agents can reduce
- There is also quite a heavy emphasis on hydrolysis of esters and amides reactions in this paper: Q24, 28, 29, 30
- Commonly tested concepts which were not present in this paper: Strength of R-X bond (Topic on halogenoalkane was tested in P2/Q3)

<u>Difficult Questions</u>

Qn 7 and 10: Requires the ability to interpret the information and data required involving partial pressure and finding oxidation number respectively

Qn 16: This can be a difficult question for many students as it requires students to link their knowledge acquired in the topics of Group 17 Elements and Chemical Energetics together.

Qn 23: Can be a difficult question for many students as you may not be familiar with the skeletal formulae drawn.

Qn 30: Can be a difficult and time consuming question to observe the reactant required to form the four fragments after hydrolysis

2018 A Level H2 Chemistry P1 Suggested Answer Key (9729)

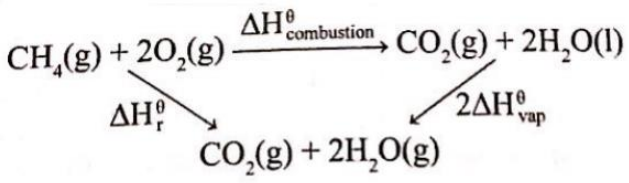
30 marks, 15% weightage

1	**D**	6	**D**	11	**C**	16	**A**	21	**C**	26	**B**
2	**D**	7	**C**	12	**D**	17	**B**	22	**A**	27	**B**
3	**D**	8	**C**	13	**A**	18	**A**	23	**B**	28	**C**
4	**B**	9	**C**	14	**A**	19	**C**	24	**D**	29	**D**
5	**C**	10	**B**	15	**A**	20	**D**	25	**A**	30	**D**

Detailed Solutions

Qn	Ans	Detailed Explanations
1	D	• Easy question on topic of atomic structure. • We choose the option where protons deflect to the negative plate and protons deflect less compared to electrons. • This is because angle of deflection is proportional to charge to mass ratio. Protons and electrons have the same charge but protons have larger mass.
2	D	• Easy question on topic of chemical bonding. • Dative bond in Al_2Cl_6 is formed when Cl donate electrons to Al. • $AlCl_3$ is a covalent compound and not ionic compound as Al^{3+} has high charge density.
3	D	• Topic: Chemical Bonding • CSe_2 is non polar. C atom forms double bond with Se atoms. Hence, C atom does not have any lone pair of electrons. The shape of CSe_2 is thus linear with no net dipole moments. • CCl_4 is also non polar as the dipole moments cancel out. • $SeCl_2$ is polar as Se atom forms single bond with Cl. Hence, Se atom still has 2 lone pair of electrons, causing $SeCl_2$ to have a bent shape and net dipole moments exist.
4	B	• Topic: Atomic Structure and Chemical Energetics • Energy need to be supplied for all 3 reactions in order to remove electron from the atom/ion. • Cs^+, I^- and Xe all have the same number of electrons. • However, Cs^+ has the greatest number of protons while I^- has the least number of protons. • As the nuclear charge increases, the attraction for the outermost electrons increases, making the enthalpy change more endothermic and greater in magnitude. Hence, the order of decreasing enthalpy change should be $\Delta H_1 > \Delta H_3 > \Delta H_2$
5	C	• Topic: Atoms, molecules and stoichiometry • Option A is incorrect as 1 mole of compound has greater than 1 mole of atoms within the compound. • Option B is incorrect as relative isotopic mass only examines the mass of one isotope, not considering the mass of all the isotopes of lithium. • Option C is correct. The relative atomic mass of oxygen is given by the expression instead, where we should compare against the mass of one atom of carbon, not one molecule: $\frac{\text{Average mass of one atom of oxygen}}{\frac{1}{12}\text{ the mass of one atom of carbon-12}}$

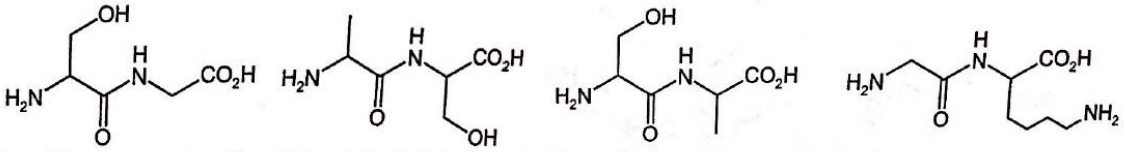
Qn	Ans	Detailed Explanations
		• For those taking H2 Physics, you should know that the average mass of one atom of oxygen is approximately equal to 8u where u=1.66x10^{-27}kg, 1/12 the mass of one atom of carbon atom is approximately equal to u. Hence, the relative atomic mass of oxygen is 8. • Option D is incorrect. The relative molecular mass of a compound E should be given by the following expression instead. $\frac{\text{Average mass of one molecule of E}}{\frac{1}{12}\text{ the mass of one atom of carbon-12}}$
6	D	• Topic: Atomic Structure • Rb and In are lower down the group compared to Br and K. Hence, they will have greater atomic radius. • Across the period, atomic radius decreases as nuclear charge increases, resulting in stronger attraction between nucleus and valence electrons. • Hence, Rb will have greatest atomic radius.
7	C	• Topic: Ideal gas on partial pressure and interpretation of data. • The partial pressure of oxygen at sea level is 0.2x1=0.2bar, based on first sentence of the paragraph. One fifth of the air is oxygen means that the molar ratio of oxygen against total air is 0.2. • This partial pressure is also equal to the partial pressure of oxygen in the bank based on the third sentence of the paragraph. • Since $\frac{n_{O_2}}{n_{Total}} \times 4 = 0.2 \Rightarrow \frac{n_{O_2}}{n_{Total}} = 0.05$ • Hence, the percentage of oxygen in the tank is 5%.
8	C	• Topic: Definitions of enthalpy change in Chemical Energetics • Option A is incorrect as it should just be $\Delta H^{\theta}_{\text{lattice energy}}\ (Al_2O_3(s))$ • Option B is incorrect as it should be $2\Delta H^{\theta}_{\text{neutralisation}}$ • Option C is correct. The equation $CaCl_2(s) + aq \rightarrow Ca^{2+}(aq) + 2Cl^-(aq)$ corresponds to $\Delta H^{\theta}_{\text{solution}}\ (\text{CaCl}_2(s))$ • Option D is incorrect as it should be $8\Delta H^{\theta}_{\text{formation}}\ (SO_2(\text{g}))$ • Note that besides looking out for the stoichiometric coefficients, it is also important to look out for state symbols (Tested in 2019 A Level P1/Q12)
9	C	• Topic: Chemical Energetics • The enthalpy change should be positive as energy needs to be absorbed to convert water into steam. Hence, answer can only be option C or D. • We need to break 4 C-H bonds, 2O=O bonds. • Then we need to form 2C=O bonds and 4O-H bonds.

Qn	Ans	Detailed Explanations
		After drawing the energy cycle,  $\Delta H_r = -2(805) - 4(460) + 4(410) + 2(496) + 890 = +72kJ$ • However, since the equation above has 2 moles of H_2O, we will have to take the value and divide by 2 to give +36kJmol^{-1} to calculate the standard enthalpy change of vaporization of water.
10	B	• Topic: Redox reaction, can be challenging for some students • The reaction between the oxide that contains iodine atoms and potassium iodide is a redox reaction where the oxide is reduced and KI is oxidised. • From Data Booklet, for oxidation of KI: $2I^- \rightarrow I_2 + 2e^-$ • Hence, 0.01 mole of KI should only give 0.005 mole of I_2. Thus the iodine oxide should contribute 0.001 mole of I_2 after the reaction has taken place, given that there is a total of 0.006 mole of I_2 produced. • Number of moles of electrons involved in reaction =Number of moles of KI = 0.01 mol. • Now, we have information that 0.001 mole of the oxide needs to produce and contribute 0.001 mole of the I_2, and the no. of moles of electrons involved in reaction is 0.01 (10 times the value), we can then write out the half equation where these conditions are fulfilled to figure out the oxidation number of iodine. $I_2O_5 + 10e^- \rightarrow I_2 + 2.5O_2$ • Hence, the oxidation number of iodine is +5.
11	C	• Topic: Reaction Kinetics on 2 step mechanism for reactions • Based on the slow step reactions, answer can only be option B or C to satisfy the rate equation. • By cancelling out the intermediates in the reactions provided, we can find out which option fulfills the overall equation of chemical reaction. • For option B, we will have $CO + 2NO_2 \rightarrow O + CO_2 + 2NO$ which is not the correct overall chemical reaction. • For option C, we will have $CO + NO_2 \rightarrow CO_2 + NO$ which is the correct overall chemical reaction.
12	D	• Topic: Reaction Kinetics on reactions involving enzyme and substrate • For a fixed amount of the enzyme catalase, there is a finite number of active sites in the enzyme. • When $[H_2O_2]$ is low, not all sites are occupied so reaction rate is proportional to $[H_2O_2]$. • However, when $[H_2O_2]$ is high, all the active sites are occupied so increase in $[H_2O_2]$ will have no effect on rate of reaction.

Qn	Ans	Detailed Explanations
13	A	• Topic: Periodicity • Al^{3+} has the highest charge density so it would polarize the surrounding water molecules, causing them to give up H^+ ions, making the solution acidic.
14	A	• Topic: Acid-base equilibria involving K_w • When temperature increases, there is greater dissociation so pH becomes lower. • However, the concentration of H^+ and OH^- are still equal to one another. • A common mistake made by student is to choose option B for this question.
15	A	• Topic: Acid-base equilibria on buffer solution • To maintain pH at 10, we will need an alkaline buffer which is made by mixing weak base and its conjugate acid. This is only satisfied by option A. • Ammonia will be able to neutralise small amount of H^+ added to the buffer solution while ammonium chloride is able to neutralise small amount of OH^- added to the buffer solution. <u>Equations depicting how neutralisations take place</u> $NH_3 + H^+ \rightarrow NH_4^+$ $NH_4^+ + OH^- \rightarrow NH_3 + H_2O$
16	A	• Concept: Group 17 Elements, can be a difficult question for many students. • Option 1 is correct. Since silver chloride dissolves in dilute $NH_3(aq)$ whereas silver bromide is only soluble in concentrated $NH_3(aq)$, this shows that dissolving silver chloride in NH_3 is more spontaneous compared to dissolving silver bromide in NH_3. As a result, $(\Delta G_1 + \Delta G_2) < (\Delta G_3 + \Delta G_4)$. • Option 2 is correct while 3 is incorrect. $\Delta G_2 = \Delta G_4$ because equations 2 and 4 are showing the same reactions where the complex ion $[Ag(NH_3)]^+$ is being formed. Cl^- and Br^- are just spectator ions so ΔH and ΔS are the same. • Option 4 showing $\Delta G_1 < \Delta G_3$ is correct. Based on our background knowledge, we should know that silver chloride is more soluble than silver bromide in water. Hence, the reaction of $AgCl(s) \rightleftharpoons AgCl(aq)$ will be more spontaneous than the reaction of $AgBr(s) \rightleftharpoons AgBr(aq)$.
17	B	• Topic: Electrochemistry • From the E^θ values provided, we should observe that H_2O_2 would be reduced rather than oxidised. Thus, KI would be oxidised. • When H_2O_2 is reduced, $E_{cell} = 1.77 - 0.54 = +1.23 > 0$. Hence, the redox reaction is feasible. • Hence, there would not be any effervescence formed when water is evolved. • The solution will turn brown due to formation of I_2. If you are unsure about the colour, do refer to the Data Booklet Qualitative Analysis Section.

Qn	Ans	Detailed Explanations
18	A	• Topic: Transition Element on colour and solubility • Option A is correct as the dark blue solution is due to the presence of $[Cu(NH_3)_4(H_2O)_2]^{2+}$ complex ion. • Option B is incorrect as $[Cu(NH_3)_6]^{2+}SO_4^{2-}$ should be a dark blue solution due to the presence of $[Cu(NH_3)_6]^{2+}$ complex ion. Thus, no precipitate should be formed. • Option C is incorrect as $Cu(OH)_2(H_2O)_4$ should be blue precipitate, and not pale blue solution. • Option D is incorrect as Cu^+ has completely filled d orbitals so there should not be any colour by the complex ion as d-d transition is not possible.
19	C	• Topic: Transition Element on ligand exchange • For option C, 1 of the H_2O ligand has been replaced by SO_4^{2-} ligand. Thus it represents a ligand exchange reaction. • In contrast, options A, B and D all involve redox reactions instead. • For option A, Cu^{2+} in $CuCl_2$ is reduced to Cu^+ in $CuCl_2^-$ while Cu metal is oxidised to Cu^+ in $CuCl_2^-$ • For option B, Cu^{2+} in $CuSO_4$ is reduced to Cu metal while Zn metal is oxidised to Zn^{2+} in $ZnSO_4$. • For option D, the oxidation state of Mn is reduced from +7 in MnO_4^- to +2 in Mn^{2+} while Fe^{2+} is oxidised to become Fe^{3+}.
20	D	• Topic: Transition element on density of transition metal compared to group 2 metal. • Vanadium is more dense compared to calcium. • 1 is incorrect as the increase in shielding effect is considered minimal in vanadium. This is because the 3 additional 3d electrons provide relatively poor shielding to the outermost 4s electrons because they occupy highly diffused d orbitals. • 2 is incorrect as vanadium and calcium have the same number of outershell electrons i.e. 2 in quantum shell 4. • 3 is correct because there is greater effective nuclear charge due to greater number of protons present in the nucleus of vanadium compared to calcium. Hence, the valence 4s electrons are attracted more strongly to the nucleus, resulting in a smaller atomic radius and higher density.
21	C	• Topic: Definition of carbocation in Organic Chemistry • Answer cannot be option A. $[CH_3OH_2]^+$ will have positive charge residing on the oxygen atom instead of the carbon atom. • Answer cannot be options B or D. This is because the positive charge in $[(CH_3)_4N]^+$ resides on the nitrogen atom instead of the carbon atom. • Answer is option C. By drawing, $[CH_3CO]^+$ and $[(CH_3)_3C]^+$ are possible carbocations.
22	A	• Topic: Carbonyl compounds, oxidation of aldehyde by Tollen's reagent • Straight forward question. • To be oxidised by Tollen's reagent, there needs to be aldehydes present which is only present in option A.

Qn	Ans	Detailed Explanations
23	B	• Topic: Isomers, can be a difficult question for many students as you may not be familiar with the skeletal formulae drawn. • Molecule 1 only has 1 chiral centre and does not contain a plane of symmetry. Hence, it is optically active and will rotate plane polarized light. • Molecule 2, 3 and 4 have 2 chiral centres. However, molecules 3 and 4 are considered as meso compounds with a plane of symmetry and they are superimposable on mirror images. • Molecule 2 does not have a plane of symmetry so it is optically active and can rotate plane polarized light.
24	D	• Topic: Multiple roles that NaOH can partake in • NaOH can react with phenol groups, carboxylic acid groups and cause hydrolysis of ester group. • There are 4 phenol groups present, 1 carboxylic acid group present and 1 ester group present in rosmarinic acid. • Thus rosmarinic acid will react with 6 moles of NaOH.
25	A	• Topic: Halogenoalkane on S_N1 and S_N2 nucleophilic substitution mechanisms • 1 is correct. Inversion of configuration occurs in the 1 step S_N2 nucleophilic substitution mechanism. • 2 is correct when a chiral carbon in the product is present after 2 step S_N1 nucleophilic substitution mechanism • 3 is correct as well as tertiary chloroalkanes have electron donating alkyl groups to stabilise the carbocation intermediate. Hence, nucleophilic substitution will take place via S_N1 mechanism.
26	B	• Topic: Carboxylic acid on factors determining strength of acid. • Choose the correct explanation where the conjugate base of 2-hydroxybenzoic acid can form internal hydrogen bonding, thus stabilising it.
27	B	• Topic: Types of compounds that reducing agents can reduce • Reaction 1 is correct as hydrogen gas can only reduce the alkene group but not the carboxylic acid group. • Reaction 2 is incorrect as $LiAlH_4$ does not reduce alkene group. • Reaction 3 is incorrect as hydrogen gas should only reduce the alkene group and not the carboxylic acid group. • Reaction 4 is correct as $LiAlH_4$ can reduce the carboxylic acid group but not the alkene group.
28	C	• Topic: Hydrolysis of ester • Option C is the correct reason why the oxygen isotope appears in the carboxylic acid product, based on C-O single bond in ester having to be broken. • Option B shows the wrong bond to break. • Options A and D are incorrect deductions.

Qn	Ans	Detailed Explanations
29	D	• Topic: Basic hydrolysis of amide • Basic hydrolysis will result in the products as shown in option D where we have carboxylate salt and phenylamine group present.
30	D	• Topic: Hydrolysis of amides, can be a difficult and time consuming question to observe the reactant required to form the four fragments after hydrolysis.  • Hydrolysis of the reactant in option A does not result in the formation of the third fragment. • Hydrolysis of the reactant in option B does not result in the formation of the second and third fragment. • Hydrolysis of the reactant in option C does not result in the formation of the third fragment. • For option D, the first fragment is obtained by breaking the second and fourth amide bond, then extracting the middle compound. • The second fragment is obtained by breaking the first and the third amide bond, then extracting the middle compound. • The third fragment is obtained by breaking the second amide bond and extract the compound to the left. • The fourth fragment is obtained by breaking the fourth amide bond and extract the compound to the right.

End of Solutions