IB SL 8 EQ Paper 2 Section A & Section B 16w to 99s 279 marks

Before 2016 paper 2 was included 4 section B questions, of which you had to chose 2. After 2016 all questions became compulsory on Paper 2

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**SL PAPER 1**
Percentage of all marks awarded for each topic from w2012 to w2014, TZ 0, 1 & 2 (red crosses) and for P1 just in 2016 s,w and SP (Green)

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<td>5.6</td>
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**STANDARD Level PAPER 2**
Percentage of all marks awarded for each topic from s1999 to w2014 for Paper 2 sections A (compulsory), B (Choose 1 Q out of 3) and A+B. From s2016 onwards, all Paper 2 questions are compulsory

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All topics ranked according to their impact on your final grade using exam papers from 1999 to 2016

| TOPICS and IA | IA | 10 | Option | N.ofSci | 4 | 5 | 8 | 3 | 1 | 9 | 7 | 6 | 2 | 11 |
|---------------|----|----|--------|--------|---|---|---|---|---|---|---|---|---|---|---|
| Paper 1       | 12.8 | 14.8 | 10.2 | 7.1 | 8.5 | 14.8 | 8.2 | 6.0 | 6.8 | 4.8 | 6.0 |
| Paper 2 16 to 08 | 23.5 | 10.9 | 10.3 | 9.8 | 5.1 | 6.8 | 11.4 | 7.1 | 7.5 | 7.0 | 0.7 |
| Paper 2 07 to 99 | 21.4 | 12.6 | 9.8 | 12.1 | 12.5 | 4.1 | 5.9 | 9.5 | 7.3 | 4.9 | 0.0 |
| Paper 2 ALL   | 22.4 | 11.8 | 10.0 | 10.9 | 8.8 | 5.5 | 8.6 | 8.3 | 7.4 | 6.0 | 0.3 |
| Paper 3       | 0.0 | 57.1 | 42.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total % All Marks, Weighted | 20 | 11.5 | 11.4 | 8.6 | 7.7 | 6.1 | 5.8 | 5.2 | 5.1 | 5.1 | 4.5 | 4.3 | 3.4 | 1.3 |
| Rank Order    | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |

Essentially, Nature of Science (NoS) is almost half of the paper, sections after 6, so 7, 8 9 & 10 are only found in HL.

This is older data and will be updated in late 2019 (I stopped teaching IB in 2016, teaching A levels instead and started again in the second half of 2019).
Standard and Higher Level components compared

Essentially, IA has the exact same weight, the Option in HL is almost 50% more important than in SL but Topic 10 is more important in SL than HL. All other topics contribute almost equally to a SL and HL grade.
The dark blue bars are where your final IB grade will be from:

1. Your IA is the single most important part of your IB SL, more important than even the Option. Imagine how much time in class, at home and in revision you have or will give to topics 9, 10 and 11. **Your IA, on average, will be worth more to your final grade than all those combined.**
2. The Option is the most important topic for your IB grade compared to the everything else
3. Topic 10, Organic Chemistry, is by far the most important topic for papers 1 and 2.
Name

Q# 1/ IB Chem/2016/w/TZ0/Paper 2 Section A/Standard Level/Q3
3. Sodium thiosulfate solution reacts with dilute hydrochloric acid to form a precipitate of sulfur at room temperature.

\[ \text{Na}_2\text{S}_2\text{O}_3 \text{(aq)} + 2\text{HCl (aq)} \rightarrow \text{S(s)} + \text{SO}_2 \text{(g)} + 2\text{NaCl (aq)} + \text{X} \]

(a) Identify the formula and state symbol of X. [1]


(b) Suggest why the experiment should be carried out in a fume hood or in a well-ventilated laboratory. [1]

Q# 2/ IB Chem/2016/w/TZ0/Paper 2 Section A/Standard Level/Q2
2. The concentration of a solution of a weak acid, such as ethanedioic acid, can be determined by titration with a standard solution of sodium hydroxide, NaOH(aq).

(a) Distinguish between a weak acid and a strong acid. [1]

Weak acid:


Strong acid:


(b) Suggest why it is more convenient to express acidity using the pH scale instead of using the concentration of hydrogen ions. [1]

Q# 3/ IB Chem/2016/SP/TZ0/Paper 2 Section A/Standard Level/Q2(a)
(vii) Sulfuric acid, H\textsubscript{2}SO\textsubscript{4}, can be described as a Bronsted–Lowry acid. State what you understand by this description. [1]
(viii) The hydrogen sulfate anion, $\text{HSO}_4^-$, is amphiprotic, so can act as an acid or a base. In the reaction of $\text{HSO}_4^-$ with the hydronium cation, $\text{H}_3\text{O}^+$, identify the two species acting as bases.

\[ \text{HSO}_4^-(aq) + \text{H}_3\text{O}^+ (aq) \rightleftharpoons \text{H}_2\text{SO}_4(aq) + \text{H}_2\text{O} (l) \]  \([1]\)

2. Impurities cause phosphine to ignite spontaneously in air to form an oxide of phosphorus and water.

(b) Phosphorus Oxide reacts with water.

(ii) Predict how dissolving an oxide of phosphorus would affect the pH and electrical conductivity of water. \([1]\)

\[
\text{pH:} \\
\text{Electrical conductivity:}
\]

(iii) Suggest why oxides of phosphorus are not major contributors to acid deposition. \([1]\)

(iv) The levels of sulfur dioxide, a major contributor to acid deposition, can be minimized by either pre-combustion and post-combustion methods. Outline one technique of each method. \([2]\)

\[
\text{Pre-combustion:} \\
\text{Post-combustion:}
\]
Q# 5/ IB Chem/2016/s/TZ0/Paper 2 Section A/Standard Level/Q1

1. Phosphine (IUPAC name phosphane) is a hydride of phosphorus, with the formula PH$_3$.

(b) 

(iii) The ion H$_2$PO$_4$\(^{-}\) is amphiprotic. Outline what is meant by amphiprotic, giving the formulas of both species it is converted to when it behaves in this manner. [2]

Q# 6/ IB Chem/2013/sQ1

(d) A solution of HA is a weak acid. Distinguish between a weak acid and a strong acid. [1]

(e) Describe an experiment, other than measuring the pH, to distinguish HA from a strong acid of the same concentration and describe what would be observed. [2]

Q# 7/ IB Chem/2013/s/tz1/Paper 2 Section B/Standard Level/q6

(d) (i) Define an acid according to the Lewis theory. [1]
(ii) State and explain the acid–base character of NH$_3$ and BF$_3$ according to the Lewis theory. [3]

NH$_3$  

BF$_3$

(ii) Describe how covalent bonds are formed. [1]
(iii) Compare the shapes of the two molecules and explain the difference using valence shell electron pair repulsion theory (VSEPR).

(iv) Predict and explain whether the molecules NH₃ and BF₃ are polar molecules.

(b) Nitric acid, HNO₃, is strong and nitrous acid, HNO₂, is weak.

(i) Define an acid according to the Bronsted–Lowry and Lewis theories.
(iv) Distinguish between a *strong acid* and a *weak acid* in terms of their dissociation in aqueous solution. 

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(vi) When lime was added to a sample of soil, the pH changed from 5 to 7. Calculate the factor by which the hydrogen ion concentration changes. 

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(vii) One common nitrogen-containing fertilizer is ammonium sulfate. State its chemical formula. 

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(d) Hydrogen bromide forms a strong acid when dissolved in water whereas hydrogen fluoride forms a weak acid. Distinguish between the terms *strong acid* and *weak acid*. State equations to describe the dissociation of each acid in aqueous solution. 

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(iii) Carbon dioxide and silicon dioxide can both be described as acidic oxides. Describe the pH changes that occur when each is added to separate samples of water. [2]

(iii) Z is an example of a weak acid. State what is meant by the term weak acid. [1]

(c) (i) Define the terms acid and base according to the Bronsted-Lowry theory and state one example of a weak acid and one example of a strong base. [2]
(ii) Describe two different methods, one chemical and one physical, other than measuring the pH, that could be used to distinguish between ethanoic acid and hydrochloric acid solutions of the same concentration. [4]

(iii) Black coffee has a pH of 5 and toothpaste has a pH of 8. Identify which is more acidic and deduce how many times the [H⁺] is greater in the more acidic product. [2]

(d) Samples of sodium oxide and sulfur trioxide are added to separate beakers of water. Deduce the equation for each reaction and identify each oxide as acidic, basic or neutral. [3]
Q# 14/ IB Chem/2010sQ3b
Ethanoic acid has the formula CH₃COOH

(iii) State an equation, including state symbols, for the reaction of ethanoic acid with water. Identify a Brønsted-Lowry acid in the equation and its conjugate base. [3]

Q# 15/ IB Chem/2010sQ3b

(c) The nitrite ion is present in nitrous acid, HNO₂, which is a weak acid. The nitrate ion is present in nitric acid, HNO₃, which is a strong acid. Distinguish between the terms strong and weak acid and state the equations used to show the dissociation of each acid in aqueous solution. [3]

(d) A small piece of magnesium ribbon is added to solutions of nitric and nitrous acid of the same concentration at the same temperature. Describe two observations that would allow you to distinguish between the two acids. [2]

(e) A student decided to investigate the reactions of the two acids with separate samples of 0.20 mol dm⁻³ sodium hydroxide solution.

(i) Calculate the volume of the sodium hydroxide solution required to react exactly with a 15.0 cm³ solution of 0.10 mol dm⁻³ nitric acid. [1]

(ii) The following hypothesis was suggested by the student: “Since nitrous acid is a weak acid it will react with a smaller volume of the 0.20 mol dm⁻³ sodium hydroxide solution.” Comment on whether or not this is a valid hypothesis. [1]

(f) The graph below shows how the conductivity of the two acids changes with concentration.

Identify Acid 1 and explain your choice. [2]
Q# 16/ IB Chem/2010/w/tz0/Paper 2 Section B/Standard Level/q4
(f) The reaction between $\text{N}_2\text{H}_4(aq)$ and $\text{HCl}(aq)$ can be represented by the following equation.

$$\text{N}_2\text{H}_4(aq) + 2\text{HCl}(aq) \rightarrow \text{N}_2\text{H}_6^{2+}(aq) + 2\text{Cl}^-(aq)$$

(i) Identify the type of reaction that occurs. \[1\]

Q# 17/ IB Chem/2009sQ3
(c) (i) State the acid-base nature of sodium oxide. \[1\]

(ii) State the equation for the reaction of sodium oxide with water. \[1\]

Q# 18/ IB Chem/2009/w/tz0/Paper 2 Section B/Standard Level/
6. (a) The equations of two acid-base reactions are given below.

**Reaction A**

$$\text{NH}_3(aq) + \text{H}_2\text{O}(l) \rightleftharpoons \text{NH}_4^+(aq) + \text{OH}^-(aq)$$

The reaction mixture in A consists mainly of reactants because the equilibrium lies to the left.

**Reaction B**

$$\text{NH}_2^- (aq) + \text{H}_2\text{O}(l) \rightleftharpoons \text{NH}_3(aq) + \text{OH}^- (aq)$$

The reaction mixture in B consists mainly of products because the equilibrium lies to the right.

(i) For each of the reactions A and B, deduce whether water is acting as an acid or a base and explain your answer. \[2\]

(ii) In reaction B, identify the stronger base, $\text{NH}_2^-$ or $\text{OH}^-$ and explain your answer. \[2\]

(iii) In reactions A and B, identify the stronger acid, $\text{NH}_4^+$ or $\text{NH}_3$ (underlined) and explain your answer. \[2\]

(b) Describe two different experimental methods to distinguish between aqueous solutions of a strong base and a weak base. \[5\]

(c) Two acidic solutions, X and Y, of equal concentrations have pH values of 2 and 6 respectively.

(i) Calculate the hydrogen ion concentrations in the two solutions and identify the stronger acid. \[2\]

(ii) Determine the ratio of the hydrogen ion concentrations in the two solutions X and Y. \[1\]

(d) (i) Define a Lewis acid and state an example that is not a Bronsted-Lowry acid. \[2\]
Q# 19/ IB Chem/2009/s/tz1/Paper 2 Section B/Standard Level/q6

(c) (i) Define a Brønsted-Lowry acid. [1]

(ii) Deduce the two acids and their conjugate bases in the following reaction:

\[ \text{H}_2\text{O}(l) + \text{NH}_3(aq) \rightleftharpoons \text{OH}^-(aq) + \text{NH}_4^+(aq) \] [2]

(iii) Explain why the following reaction can also be described as an acid-base reaction:

\[ \text{F}^-(g) + \text{BF}_3(g) \rightleftharpoons \text{BF}_4^-(s) \] [2]

(d) Ethanoic acid, CH₃COOH, is a weak acid.

(i) Define the term *weak acid* and state the equation for the reaction of ethanoic acid with water. [2]

(ii) Vinegar, which contains ethanoic acid, can be used to clean deposits of calcium carbonate from the elements of electric kettles. State the equation for the reaction of ethanoic acid with calcium carbonate. [2]

Q# 20/ IB Chem/2008wQ3

(b) The equation for the reaction that occurs when ammonia gas dissolves in water is shown below:

\[ \text{NH}_3(g) + \text{H}_2\text{O}(l) \rightleftharpoons \text{NH}_4^+(aq) + \text{OH}^-(aq) \]

(i) State how the equation indicates that ammonia is a base. [1]

(ii) State how the equation indicates that ammonia is a *weak* base. [1]

(iii) Identify which pH value is approximately correct for ammonia solution.

<table>
<thead>
<tr>
<th>pH</th>
<th>1</th>
<th>3</th>
<th>7</th>
<th>11</th>
<th>13</th>
</tr>
</thead>
</table>
3. (a) (i) A solution of hydrochloric acid has a concentration of 0.10 mol dm$^{-3}$ and a pH value of 1. The solution is diluted by a factor of 100. Determine the concentration of the acid and the pH value in the diluted solution. \[ \text{[2]} \]

(ii) Explain why 0.10 mol dm$^{-3}$ ethanoic acid solution and the diluted solution in (a) (i) have similar [H$^+$] values. \[ \text{[3]} \]

(b) Suggest one method, other than measuring pH, which could be used to distinguish between solutions of a strong acid and a weak acid of the same concentration. State the expected results. \[ \text{[2]} \]

4. (a) Iodide ions, I$^-$(aq), react with iodate ions, IO$_3^-$ (aq), in an acidic solution to form molecular iodine and water.

(i) Determine the oxidation number of iodine in each iodine-containing species in the reaction. \[ \text{[2]} \]
(ii) Identify, with a reason, the species that undergoes:

oxidation ..................................................................................

reduction ..................................................................................

(b) Describe how electrolysis is used to plate an object with copper. Write an equation for the reaction occurring at the negative electrode (cathode).

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Q# 23/ IB Chem/2007/wTZ0/Paper 2 Section A/Standard Level/

3. (a) (i) A solution of hydrochloric acid has a concentration of 0.10 mol dm$^{-3}$ and a pH value of 1. The solution is diluted by a factor of 100. Determine the concentration of the acid and the pH value in the diluted solution.

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(ii) Explain why 0.10 mol dm$^{-3}$ ethanoic acid solution and the diluted solution in (a) (i) have similar [H$^+$] values.

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(b) Suggest one method, other than measuring pH, which could be used to distinguish between solutions of a strong acid and a weak acid of the same concentration. State the expected results.

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4. (a) Iodide ions, $I^- (aq)$, react with iodate ions, $IO_3^-(aq)$, in an acidic solution to form molecular iodine and water.

(i) Determine the oxidation number of iodine in each iodine-containing species in the reaction. [2]

(ii) Identify, with a reason, the species that undergoes: [2]

oxidation

reduction

(b) Describe how electrolysis is used to plate an object with copper. Write an equation for the reaction occurring at the negative electrode (cathode). [4]

Q# 25/ IB Chem/2007/s/tz1/Paper 2 Section B/Standard

7. (a) Explain why a 1.0 mol dm$^{-3}$ solution of sodium hydroxide has a pH of 14 whereas 1.0 mol dm$^{-3}$ ammonia solution has a pH of about 12. Use equations in your answer. [3]

(b) 20.0 cm$^3$ of a known concentration of sodium hydroxide is titrated with a solution of nitric acid. The graph for this titration is given below.
(i) State an equation for the reaction between sodium hydroxide and nitric acid. [1]

(ii) Calculate the concentration of the sodium hydroxide solution before the titration. [2]

(iii) From the graph determine the volume of nitric acid required to neutralize the sodium hydroxide and calculate the concentration of the nitric acid. [2]

(iv) Predict the volume of ethanoic acid of the same concentration as the nitric acid in (b) (iii), required to neutralize 20.0 cm$^3$ of this sodium hydroxide solution. [1]

(c) State and explain two methods, other than measuring pH, which could be used to distinguish between 1.0 mol dm$^{-3}$ solutions of nitric acid and ethanoic acid. [4]

Q# 26/ IB Chem/2006/w/tz0/Paper 2 Section B/ Standard Level/q6

(c) A titration was carried out to determine the concentration of 25.0 cm$^3$ of an aqueous solution of nitric acid. The pH value of the liquid in the flask was measured as 0.100 mol dm$^{-3}$, aqueous sodium hydroxide was added. The results are shown on the graph below.

(i) Use the graph to determine the value of $[H^+]$ of the nitric acid solution. [1]

(ii) Determine the pH value when the value of $[H^+]$ has decreased to $1 \times 10^{-3}$ mol dm$^{-3}$. [1]

(iii) Use the graph to determine the volume of 0.100 mol dm$^{-3}$ aqueous sodium hydroxide solution needed to exactly neutralize the nitric acid. [1]

(iv) Calculate the concentration, in mol dm$^{-3}$, of the nitric acid. [2]
(d) The pH values of three acidic solutions, X, Y and Z, are shown in the following table:

<table>
<thead>
<tr>
<th>Solution</th>
<th>Acid</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>HCl(aq)</td>
<td>2</td>
</tr>
<tr>
<td>Y</td>
<td>HCl(aq)</td>
<td>4</td>
</tr>
<tr>
<td>Z</td>
<td>CH₃COOH(aq)</td>
<td>4</td>
</tr>
</tbody>
</table>

(i) Solutions X and Z have the same acid concentration. Explain, by reference to both acids, why they have different pH values. [2]

(ii) Deduce by what factor the values of [H⁺] in solutions X and Y differ. [1]

Q# 27/ IB Chem/2006/s/tz1/Paper 2 Section B/Standard Level/

8. (a) Identify one example of a strong acid and one example of a weak acid. Outline three different methods to distinguish between equimolar solutions of these acids in the laboratory. State how the results would differ for each acid. [3]

(b) State the name used to describe substances that can act as an acid and a base. Use equations to illustrate how HCO₃⁻ can behave both as an acid and base. [3]

(c) Vinegar has a pH of approximately 3 and some detergents have a pH of approximately 8. State and explain which of these has the higher concentration of H⁺ and by what factor. [1]

Q# 28/ IB Chem/2005/w/tz0/Paper 2 Section B/Standard Level/ q6

(b) The pH values of solutions of three organic acids of the same concentration were measured.

<table>
<thead>
<tr>
<th>acid</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>5</td>
</tr>
<tr>
<td>Y</td>
<td>2</td>
</tr>
<tr>
<td>Z</td>
<td>3</td>
</tr>
</tbody>
</table>

(i) Identify which solution is the least acidic. [1]

(ii) Deduce how the [H⁺] values compare in solutions of acids Y and Z. [2]

(iii) Arrange the solutions of the three acids in decreasing order of electrical conductivity, starting with the greatest conductivity, giving a reason for your choice. [2]

Q# 29/ IB Chem/2004/w/TZ0/Paper 2 Section A/Standard Level/

4. A 0.01 mol dm⁻³ solution of hydrochloric acid has a pH value of 2. Suggest, with a reason, the pH values of

(a) 0.10 mol dm⁻³ hydrochloric acid. [2]
Q# 30/ IB Chem/2003/s/tz1/Paper 2 Section B/Standard Level/

7. (a) Define the terms **strong acid** and **weak acid**. Using hydrochloric and ethanoic acid as examples, write equations to show the dissociation of each acid in aqueous solution.

(b) (i) Calcium carbonate is added to separate solutions of hydrochloric acid and ethanoic acid of the same concentration. State one similarity and one difference in the observations you could make.

(ii) Write an equation for the reaction between hydrochloric acid and calcium carbonate.

(iii) Determine the volume of 1.50 mol dm\(^{-3}\) hydrochloric acid that would react with exactly 1.25 g of calcium carbonate.

(iv) Calculate the volume of carbon dioxide, measured at 273 K and 1.01×10\(^5\) Pa, which would be produced when 1.25 g of calcium carbonate reacts completely with the hydrochloric acid.

(c) The graph below shows the change in pH when aqueous sodium hydroxide is added to 20 cm\(^3\) of aqueous hydrochloric acid.
By reference to the graph

(i) state the [H+] before any alkali is added. \[1\]

(ii) state how much the [H+] changes after the addition of 20 cm³ of aqueous sodium hydroxide. \[1\]

(iii) determine the volume of the same sodium hydroxide solution needed to neutralize 20 cm³ of aqueous ethanoic acid of the same concentration as the hydrochloric acid. \[1\]

Q# 31/ IB Chem/2002/w/tz0/Paper 2 Section B/Standard Level/

5. Carbonic acid (H₂CO₃) is described as a weak acid and hydrochloric acid (HCl) is described as a strong acid.

(a) Explain, with the help of equations, what is meant by strong and weak acid using the above acids as examples. \[4\]

(b) Outline two ways, other than using pH, in which you could distinguish between carbonic acid and hydrochloric acid of the same concentration. \[4\]

(c) A solution of hydrochloric acid, HCl(aq), has a pH of 1 and a solution of carbonic acid, H₂CO₃(aq), has a pH of 5. Determine the ratio of the hydrogen ion concentrations in these solutions. \[2\]

(d) The relative strengths of acids can be illustrated by the following equation.

\[\text{HCO}_3^- (aq) + \text{HCl}(aq) \rightleftharpoons \text{H}_2\text{CO}_3(aq) + \text{Cl}^- (aq)\]

(i) Identify the acid and its conjugate base and the base and its conjugate acid in the above equation. \[2\]

(ii) Name the theory that is illustrated in (d) (i). \[1\]

(e) Give examples of both a strong base and a weak base, clearly indicating which is which. \[2\]

(f) Give an equation for the reaction between carbonic acid and one of the bases given in (e). \[2\]

(g) Carbonic acid can be used to treat wasp (an insect) stings.

(i) Suggest what this indicates about the nature of wasp stings. \[2\]

(ii) Name the type of reaction that occurs. \[2\]

(iii) Explain why hydrochloric acid is not used to treat wasp stings. \[3\]
2. In aqueous solution, sodium hydroxide is a strong base and ammonia is a weak base.

(a) Use the Brønsted–Lowry theory to state why both substances are classified as bases. \[1\]

(b) Solutions of 0.1 mol dm\(^{-3}\) sodium hydroxide and 0.1 mol dm\(^{-3}\) ammonia have different electrical conductivities.

(i) State and explain which solution has the greater conductivity. \[1\]

(ii) The pH value of 0.1 mol dm\(^{-3}\) ammonia solution is approximately 11. State and explain how the pH value of the 0.1 mol dm\(^{-3}\) sodium hydroxide solution would compare. \[2\]

(c) Write an equation to show the reaction of ammonia with water and classify each product as a Brønsted–Lowry acid or base. \[2\]

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Q# 33/ IB Chem/2001sQ3

(c) State, giving a reason, which reactant in the following equation is acting as an oxidising agent:

\[\text{Ca} + \text{F}_2 \rightarrow \text{CaF}_2\] 

\[2\]
7. Five unlabelled bottles are known to contain the following 0.10 mol dm\(^{-3}\) aqueous solutions:

\[ \text{CH}_3\text{COOH}, \text{NaCl}, \text{NaOH}, \text{HCl}, \text{NH}_3 \]

(a) Describe and explain how the pH values of these five solutions could be used to identify them. \([5]\)

(b) Experiments were conducted to illustrate some properties of sodium hydrogen carbonate, NaHCO\(_3\).

(i) In one experiment some solid NaHCO\(_3\) was added to aqueous NaOH. After stirring the pH decreased to 9. Write a balanced chemical equation for the reaction and explain the decrease in pH. \([2]\)

(ii) In another experiment solid NaHCO\(_3\) was added to an aqueous solution of HCl. After stirring the pH increased to 5. Write a balanced equation for the reaction and explain this result. \([2]\)

(c) Describe how the two reactions of NaHCO\(_3\) in (b) illustrate the Bronsted–Lowry theory of acids and bases. \([2]\)

(d) The graph below shows how the conductivity of a strong and a weak monoprotic acid change as the concentration changes:

\[ \text{Conductivity} \]

![Conductivity graph](image.png)

(i) Identify the strong acid and the weak acid from the above data. Give reasons for your choices. \([6]\)

(ii) Describe how magnesium metal can be used to distinguish between solutions of the strong acid and the weak acid of the same concentration. \([2]\)

(iii) Compare the volume of 0.10 mol dm\(^{-3}\) NaOH required to react exactly with 10.0 cm\(^3\) of 0.10 mol dm\(^{-3}\) solutions of each of these acids. \([1]\)
2. Sodium hydrogencarbonate dissolves in water forming an alkaline solution according to the following ionic equilibrium:

\[ \text{HCO}_3^- (aq) + \text{H}_2\text{O}(l) \rightleftharpoons \text{H}_2\text{CO}_3 (aq) + \text{OH}^- (aq) \]

(a) Why is the solution alkaline? [1]

(b) Using the Bronsted–Lowry theory, state, with a brief explanation, whether the \text{HCO}_3^- ion is behaving as an acid or as a base. [2]

(c) Identify the conjugate base of carbonic acid, \text{H}_2\text{CO}_3. [1]

Q# 36/ IB Chem/2000/w/TZ0/Paper 2 Section A/Standard Level/

1. 25.0 cm$^3$ of hydrochloric acid of known concentration is titrated with a dilute sodium hydroxide solution. The pH of the mixture is measured continuously as shown in the graph below:

![Graph showing pH vs. volume of NaOH](image)

(a) (i) From the graph, determine the pH after 10.0 cm$^3$ of sodium hydroxide solution is added. [1]

(ii) Determine the concentration of hydrochloric acid before titration and state its units. [2]
(iii) From the graph, determine the volume of sodium hydroxide solution required to neutralise the hydrochloric acid. [1]

(iv) Calculate the concentration of the sodium hydroxide solution and state its units. [1]

(b) (i) Hydrochloric acid is a strong acid, whereas ethanoic acid is a weak acid. What is the difference between a strong acid and a weak acid? [1]

(ii) What mass of ethanoic acid would you use and how would you prepare 0.500 dm³ of a 0.500 mol dm⁻³ ethanoic acid solution? (M_r of ethanoic acid = 60.0) [2]

---

Q# 37/ IB Chem/2000/s/TZ1/Paper 2 Section A/Standard Level/

1. Solutions of acids of the same concentration are prepared. The acids and their equilibrium constants, \( K_a \), are:

<table>
<thead>
<tr>
<th>Acid</th>
<th>( K_a ) (at 25°C) mol dm⁻³</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH₃COOH</td>
<td>( 1.7 \times 10^{-5} )</td>
</tr>
<tr>
<td>HCN</td>
<td>( 4.0 \times 10^{-10} )</td>
</tr>
<tr>
<td>HCl</td>
<td>very large</td>
</tr>
<tr>
<td>HF</td>
<td>( 5.6 \times 10^{-4} )</td>
</tr>
</tbody>
</table>

(a) Write down the equilibrium expression for HCN. [2]

(b) Write down these solutions in order of decreasing pH. [1]

(c) Write down these solutions in order of increasing concentration of molecules of acid present in the solution. [1]
(c) Write down these solutions in order of increasing concentration of molecules of acid present in the solution. [1]

(d) For the solution of CH₃COOH, write down the formulas of all the chemical species present. [1]

(e) Write the name and formula of the conjugate base of HF. [2]

(f) State, giving a reason, an experimental method other than pH measurement, that would distinguish between the solutions of HCl and HF. [2]

Q# 38/ IB Chem/1999/w/TZ0/Paper 2 Section A/Standard Level/

3. Ethanoic acid, CH₃COOH, is a weak acid.

(a) What is meant by the term weak acid? [1]

(b) Give the equation for the reaction of ethanoic acid with water and clearly identify all the Brønsted-Lowry acids and bases. [3]

(c) Give the structural formula for the conjugate base of ethanoic acid. [1]
6. (a) By means of balanced equations, give three different types of chemical reaction of an acid, such as aqueous sulphuric acid. \[3\]

(b) (i) Define an acid and a base according to the Brønsted–Lowry theory. \[1\]

(ii) Ammonia acts as a base in water. Write a balanced equation for this reaction and state what would be observed if the final solution were tested with pH paper. \[3\]

(c) In the following reactions identify clearly the acid, conjugate base, base and conjugate acid:

(i) \[\text{HNO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{H}_2\text{NO}_3^+ + \text{HSO}_4^-\] \[1\]

(ii) \[\text{CH}_3\text{CH}_2\text{NH}_2 + \text{H}_2\text{O} \rightarrow \text{OH}^- + \text{CH}_3\text{CH}_2\text{NH}_3^+\] \[1\]

(d) Using the equation (i) in (c), state and explain the relative strengths of nitric and sulphuric acid. \[2\]

(e) What is the difference between a strong acid and a weak acid? How could you distinguish between them experimentally? \[4\]

(f) Two acidic solutions, A and B, of equal concentration, have pH values of 2 and 6 respectively.

(i) Indicate which acid is stronger and calculate how many times more acidic it is. \[3\]

(ii) Give two ways in which solution A could be treated to produce a solution of pH 6. \[2\]

---

Mark Scheme IB SL 8 EQ Paper 2 16w to 99s 279marks

---

Q# 1/ IB Chem/2016/w/TZ0/Paper 2 Section A/Standard Level/Q3

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Notes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. a</td>
<td>H$_2$O (aq) (ii) ✓</td>
<td>Do not accept H$_2$O (aq).</td>
<td>1</td>
</tr>
<tr>
<td>b</td>
<td>SO$_3$ (g) is an irritant/causes breathing problems OR SO$_2$ (g) is poisonous/toxic ✓</td>
<td>Accept SO$_2$ (g) as acidic, but do not accept &quot;causes a strong acid rain&quot;. Accept SO$_2$ (g) is harmful. Accept SO$_2$ (g) has a foul/pungent smell.</td>
<td>1</td>
</tr>
</tbody>
</table>

Q# 2/ IB Chem/2016/w/TZ0/Paper 2 Section A/Standard Level/Q2

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Notes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. a</td>
<td>Weak acid: partially dissociated/ionized in solution/water AND Strong acid: assumed to be almost completely/100% dissociated/ionized in solution/water ✓</td>
<td>Accept answers relating to pH, conductivity, reactivity if solutions of equal concentrations stated.</td>
<td>1</td>
</tr>
<tr>
<td>2. b</td>
<td>log scale reduces a wide range of numbers to a small range OR simple/easy to use OR converts exponential expressions into linear scale/simple numbers ✓</td>
<td>Do not accept &quot;easy for calculations&quot;.</td>
<td>1</td>
</tr>
</tbody>
</table>

Q# 3/ IB Chem/2016/SP/TZ0/Paper 2 Section A/Standard Level/Q2

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>a viii</td>
<td>proton donor ✓</td>
<td>1</td>
</tr>
<tr>
<td>a viii</td>
<td>HSO$_4^-$ (aq) and H$_2$O (l) ✓</td>
<td>1</td>
</tr>
</tbody>
</table>
Q# 4/ IB Chem/2016/s/TZ0/Paper 2 Section A/Standard Level/Q2

2. b ii pH decreases AND electrical conductivity increases. ✓

2. b iii phosphorus not commonly found in fuels OR no common pathways for phosphorus oxides to enter the air OR amount of phosphorus-containing organic matter undergoing anaerobic decomposition is small ✓

Accept "phosphorus oxides are solids so are not easily distributed in the atmosphere". Accept "low levels of phosphorus oxide in the air". Do not accept "H₅PO₄ is a weak acid". ✓

Q# 5/ IB Chem/2016/s/TZ0/Paper 2 Section A/Standard Level/Q1

1. b iii can act as both a Bronsted-Lowry acid and a Bronsted-Lowry base OR can accept and/or donate a hydrogen ion/proton/H⁺ ✓

HPO₄²⁻ AND H₂PO₄ ✓

Q# 6/ IB Chem/2013/s/TZ1/Paper 2 Section B/Standard Level/Q6

(d) weak acids partially dissociated/ionized and strong acids completely dissociated/ionized (in solution/water) / OWTTE. [1]

(e) measuring electrical conductivity: strong acids have greater electrical conductivity / weak acids have lower electrical conductivity;

OR adding a reactive metal / carbonate / hydrogen carbonate; Accept correct example.

stronger effervescence with strong acids / weaker with weak acids / OWTTE;

OR adding a strong base; Accept correct example.

strong acid would increase more in temperature / weak acids increase less in temperature; [2]

Q# 7/ IB Chem/2013/s/TZ1/Paper 2 Section B/Standard Level/Q6

(d) (i) electron pair acceptor; [1]

(ii) NH₃: Lewis base;

BF₃: Lewis acid;

NH₃ has non-bonding/lone pair of electrons and BF₃ has only 3 pairs of electrons around B/incomplete octet;

Reference to outer electrons of N and B is needed for the mark. [3]
Q# 8/ IB Chem/2013/s/tz1/Paper 2 Section B/Standard Level/q6

(c) (i) \( \text{NH}_3 \quad \text{BF}_3 \)

\[
\begin{array}{c}
\text{H} - \text{N} - \text{H} \\
\text{H} \\
\end{array}
\quad \left| \begin{array}{c}
\text{F} - \text{B} - \text{F} \\
\text{F} \\
\end{array} \right|
\]

Accept any combination of lines, dots or crosses to represent electron pairs.

(ii) sharing of electrons between atoms; [1]

(iii) \( \text{NH}_3 \) (trigonal/triangular) pyramidal;
\( \text{BF}_3 \) (trigonal/triangular planar);
\( \text{NH}_3 \) has 3 negative centres of charge/three bonding pairs and one lone pair and
\( \text{BF}_3 \) has 3 negative centres of charge/three bonding pairs / OWTTE;

(sound angles) 107° in \( \text{NH}_3 \) and 120° in \( \text{BF}_3 \);

Accept 107.5° for \( \text{NH}_3 \). [4]

(iv) \( \text{BF}_3 \) not polar as no net dipole moment / BF bond polarities cancel each other cut / symmetrical distribution of charge;
\( \text{NH}_3 \) polar as net dipole moment present / NH bond polarities do not cancel each other out / unsymmetrical distribution of charge;

Accept suitable diagram showing dipole moments.

Do not accept electronegativities cancel out.

Q# 9/ IB Chem/2012/w/tz0/Paper 2 Section B/Standard Level/q5

(b) (i) Brønsted Lowry theory: proton/H⁺ donor;
Lewis theory: electron-pair acceptor; [2]

(iv) Strong acid: acid/electrolyte completely/100% dissociated/ionized in solution/water / OWTTE and Weak acid: acid/electrolyte partially dissociated/ionized in solution/water / OWTTE; [1]

(vi) changes by \( 10^3/100 \):
Allow changes from \( 10^{-5} \) to \( 10^{-7} \). [1]

(vii) \( (\text{NH}_4)_2\text{SO}_4 \); [1]

Q# 10/ IB Chem/2012/s/tz1/Paper 2 Section B/Standard Level/q6

(d) Strong acid: acid/electrolyte (assumed to be almost) 100%/completely
dissociated/ionized (in solution/water) / OWTTE and
Weak acid: acid/electrolyte
only partially/slightly dissociated/ionized (in solution/water) / OWTTE;

\( \text{HBr} \text{(aq)} \rightarrow \text{H}^+ \text{(aq)} + \text{Br}^- \text{(aq)} \);

\( \text{HF} \text{(aq)} \leftrightarrow \text{H}^+ \text{(aq)} + \text{F}^- \text{(aq)} \); [3]

Q# 11/ IB Chem/2012/s/tz1/Paper 2 Section B/Standard Level/q5b

(iii) \( \text{CO}_2 \):
\( \text{pH} \) (of resultant solution) weakly acidic / \( \text{pH} \) in range 5.5–6.5 (accept any value in this range);

\( \text{SiO}_2 \):
\( \text{pH} \) remains as 7; [2]

Q# 12/ IB Chem/2011/w/tz0/Paper 2 Section B/Standard Level/

(iii) acid partially dissociates/ionizes; [1]
Q# 13/ IB Chem/2011sq5
(c) (i) acid is a proton/H⁺ donor and base is a proton/H⁺ acceptor; 
\[ \text{H}_2\text{CO}_3/\text{CH}_3\text{COOH} \text{ and NaOH/KOH/Ba(OH)}_2; \] 
Accept any suitable examples. 

(ii) Chemical [2 max] 
reaction with reactive metal/Mg/Zn/carbonate/hydrogen carbonate; 
hydrochloric acid would react faster/more vigorously / ethanoic acid would 
react slower/less vigorously; 
\[ \text{OR} \]
react with alkali; 
temperature change will be more for hydrochloric acid / temperature change 
will be less for ethanoic acid; 
Physical [2 max] 
conductivity; 
hydrochloric acid will conduct more/higher / ethanoic acid will conduct 
less/lower; 
Accept other suitable examples. 

(iii) black coffee; 
\[ 10^7/1000 \text{ times}; \] 

(d) \[ \text{Na}_2\text{O}(s) + \text{H}_2\text{O}(l) \rightarrow 2\text{NaOH}(aq); \] 
\[ \text{SO}_3(l) + \text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{SO}_4(aq); \] 
Ignored state symbols. 
\[ \text{Na}_2\text{O}: \text{basic and SO}_3: \text{acidic}; \] 

Q# 14/ IB Chem/2010/s/TZ1/Paper 2 Section A/Standard Level/
(iii) \[ \text{CH}_3\text{COOH (aq) + H}_2\text{O (l)} \rightleftharpoons \text{CH}_3\text{COO}^-\text{(aq) + H}_3\text{O}^+\text{(aq)} \] 

OR 
\[ \text{CH}_3\text{COOH (l) + H}_2\text{O (l)} \rightarrow \text{CH}_3\text{COO}^-\text{(aq) + H}_3\text{O}^+\text{(aq)} \] 

OR 
\[ \text{CH}_3\text{COOH (aq) \rightleftharpoons CH}_3\text{COO}^-\text{(aq) + H}^+(aq) \] 
correct equation; 
state symbols and \[ \rightleftharpoons; \] 
BL acid is CH3COOH and cb is CH3COO⁻ / BL acid is H3O⁺ and cb is H2O; 

Q# 15/ IB Chem/2010/w/tz0/Paper 2 Section B/Standard Level/q6
(c) strong acid completely dissociated/ionized and weak acid partially dissociated/ionized; 
\[ \text{HNO}_3(aq) \rightarrow \text{H}^+(aq) + \text{NO}_3^-\text{(aq)}; \] 
\[ \text{HNO}_3(aq) \rightleftharpoons \text{H}^+(aq) + \text{NO}_3^-\text{(aq)}; \] 
Allow only arrows as shown. 
State symbols not needed. 
Accept \( \text{H}_2\text{O} \) and \( \text{H}_3\text{O}^+ \).
(d) With HNO₃:

- faster rate of bubble/gas/hydrogen production;
- faster rate of magnesium dissolving;
- higher temperature change; [2 max]

Accept opposite argument for HNO₃.

Award [1] if 2 observations given but acid is not identified.
Reference to specific observations needed.

(e) (i) (nitric acid) 7.5 cm³; [1]

(ii) not valid as nitrous acid reacts with same volume/7.5 cm³; [1]

(f) HNO₃;

(higher conductivity for solutions with same concentration as) there are more ions in solution; [2]

Q# 16/ IB Chem/2010/w/tz0/Paper 2 Section B/Standard Level/q4

(i) acid-base/neutralization; [1]

Q# 17/ IB Chem/2009/sQ3

(c) (i) basic; [1]

Allow alkaline

(ii) Na₂O + H₂O → 2NaOH / Na₂O + H₂O → 2Na⁺ + 2OH⁻; [1]

Do not accept ⇔

Q# 18/ IB Chem/2009/w/tz0/Paper 2 Section B/Standard Level/

6. (a) (i) acid in both reactions;

because it loses a proton/hydrogen ion/H⁺ / proton/hydrogen ion/H⁺ donor; [2]

Second mark can be scored if they do not identify it as an acid in both reactions.

(ii) NH₃⁻;

more readily accepts a proton / equilibrium lies to the right / takes H⁺ from H₂O; [2]

If OH⁻ chosen award [0]

(iii) NH₄⁺;

donates a proton more readily than NH₃ / equilibrium lies to the left; [2]

If NH₃ chosen award [0]

(b) solutions of the same concentration;

pH meter;

strong base has a higher pH / weak base has lower pH;

indicator paper/U.I solution;

strong base has a higher pH/more purple / weak base has lower pH/blue not purple / OWTTE;

measuring conductivity (with conductivity meter);

strong base has a higher conductivity / weak base has lower conductivity;

comparing heat of neutralisation with acid;

strong base releases more heat / weak base releases less heat;

Award [4 max] for two correct methods with expected results. [5]
(c) (i) \( X; \) 
\[ [X] = 10^{-2} \text{ (mol dm}^{-3}) \text{ and } [Y] = 10^{-6} \text{ (mol dm}^{-3}) \];  
\[ 10000/10^4 : 1; \]
\textit{Ratio should be in form above.}  
(ii) \text{(Lewis acid) electron pair acceptor; appropriate example (such as AlCl}_3, \text{ BF}_3 \text{ etc.).}  
\text{(ii) structural formula of Lewis acid (e.g. BF}_3, \text{ AlCl}_3, \text{ Transition element etc); structural formula of Lewis base (e.g. NH}_3, \text{ H}_2\text{O etc); structural formula of product (e.g. F}_2\text{BH}_2\text{NH}_3 \text{ etc); dative covalent (bond)/coordinate (bond);}

\[
\begin{array}{c}
\text{F} \\
\text{B} \\
\text{H}
\end{array}
\quad + 
\begin{array}{c}
\text{H} \\
\text{N} \\
\text{H}
\end{array}
\quad \rightarrow 
\begin{array}{c}
\text{F} \\
\text{B} \\
\text{N} \\
\text{H}
\end{array}
\]

\text{Lewis acid Lewis base Product}

\textit{Penalize missing structural formulas once.}

Q# 19/ IB Chem/2009/s/tz1/Paper 2 Section B/Standard Level/q6

(c) (i) donates a proton / H\(^+\) ion;  
(ii) \text{(acid) (conjugate base)} 
\[ \text{H}_2\text{O} \quad \text{OH}^{-}; \] 
\[ \text{NH}_4^+ \quad \text{NH}_3 ; \]
\textit{[1 max] if all four acids and bases given but not clearly paired.}

(iii) Lewis acid accepts an electron pair / Lewis base donates an electron pair; 
\( \text{F}^- \text{ is the base / BF}_3 \text{ is the acid;} \)

(d) (i) \text{partially dissociated or ionized;} 
\[ \text{CH}_3\text{COOH} + \text{H}_2\text{O} \Leftrightarrow \text{CH}_3\text{COO}^- + \text{H}_3\text{O}^+ / \text{CH}_3\text{COOH} \Leftrightarrow \text{CH}_3\text{COO}^- + \text{H}^+ ; \]
\textit{\( \Leftrightarrow \) required for mark.}

(ii) \[ 2\text{CH}_3\text{COOH} + \text{CaCO}_3 \rightarrow \text{Ca(CH}_3\text{COO})_2 + \text{CO}_2 + \text{H}_2\text{O} \]
\textit{Award [1] for correct reactants and products and [1] for balancing.}

Q# 20/ IB Chem/2008wQ3

(b) (i) \text{produces hydroxide/OH}^- \text{ ions / accepts a proton/H}^+ \text{ / donates pair of electrons;}

(ii) \ \Leftrightarrow / \text{reversible arrow / incomplete/partial dissociation;}

(iii) 11;
Q# 21/ IB Chem/2007/w/TZ0/Paper 2 Section A/Standard Level/

3. (a) (i) $0.0010 / 1.0 \times 10^{-3} \text{ (mol dm}^{-3}\text{)}$;  
\[ \text{pH} = 3; \]  
(ii) HCl: strong acid / fully dissociated;  
CH$_3$COOH: weak acid / partially dissociated;  
HCl less concentrated / CH$_3$COOH more concentrated;  
only one molecule in 100 dissociates in ethanoic acid so $[\text{H}^+] 1/100/ \text{OWTTE}$ [3 max]

(b) measure electrical conductivity;  
strong acids are good conductors / weak acids are poor conductors;  

OR

react with magnesium or a named active metal / (metal) carbonate;  
hydrogen carbonate/bicarbonate;  
strong acids have a faster reaction / more gas bubbles (per unit time) / more heat  
produced / weak acids have a slower reaction / less gas bubbles (per unit time) / less  
heat produced;  
Accept answers based on:  
titration curves: namely strong acid and strong base will have an equivalence point pH  
of 7 and a weak acid and strong base will have an equivalence point pH of 7.  
OR

temperature change: on neutralization for temperature change: namely, neutralization  
($\text{H}^+ + \text{OH}^-$) is exothermic, weak acid is partially dissociated so some energy used up in  
dissociation of weak acid – net result, weak acid would produce less energy / less  
temperature increase compared to neutralization of strong acid.

Q# 22/ IB Chem/2007/w/TZ0/Paper 2 Section A/Standard Level/

4. (a) (i)  
$I^- = -1/1-$  
$\text{IO}_3^- = +5/5+$  
$I_2 = 0$  

Award [2] for all three correct, [1] for any two correct,  
Signs must be included  
Do not accept Roman numerals  

(ii) \text{oxidation}  
$\text{I}^- $ (to $I_2$), increase in oxidation number / loss of electron(s);  
\text{reduction}  
$\text{IO}_3^-$ (to $I_2$), decrease in oxidation number / gain of electron(s);  

(b) object to be plated is negative electrode/cathode;  
pure copper is positive electrode/anode;  
\text{Accept inert electrode}  

(both electrodes in) solution/electrolyte of copper(II) sulfate/chloride/ $\text{CuSO}_4 / \text{CuCl}_2$;  
\text{Accept an annotated diagram showing all the information for the first [3] marks}  

$\text{Cu}^{2+} + 2e^- \rightarrow \text{Cu}$;  

[4]
Q# 23/ IB Chem/2007/w/TZ0/Paper 2 Section A/Standard Level/

3. (a) (i) $0.0010 / 1.0 \times 10^{-3}$ (mol dm$^{-3}$);

    pH = 3;  

(ii) HCl: strong acid / fully dissociated;

    CH$_3$COOH: weak acid / partially dissociated;

    HCl less concentrated / CH$_3$COOH more concentrated;

    only one molecule in 100 dissociates in ethanoic acid so [H$^+$] 1/100/ OWTTE [3 max]

(b) measure electrical conductivity;

    strong acids are good conductors / weak acids are poor conductors;

OR

react with magnesium or a named active metal / (metal) carbonate;

hydrogen carbonate/bicarbonate;

strong acids have a faster reaction / more gas bubbles (per unit time) / more heat produced / weak acids have a slower reaction / less gas bubbles (per unit time) / less heat produced;  

Accept answers based on:

    titration curves: namely strong acid and strong base will have an equivalence point pH of 7 and a weak acid and strong base will have an equivalence point pH of >7.

OR

    temperature change: on neutralization for temperature change: namely, neutralization (H$^+$ + OH$^-$) is exothermic, weak acid is partially dissociated so some energy used up in dissociation of weak acid – net result, weak acid would produce less energy / less temperature increase compared to neutralization of strong acid.

Q# 24/ IB Chem/2007/w/TZ0/Paper 2 Section A/Standard Level/

4. (a) (i) I$^-$ = $-1/1-$

    IO$_3^-$ = $+5/5+$

    $I_2$ = 0  

Award [2] for all three correct, [1] for any two correct,

    Signs must be included

Do not accept Roman numerals

(ii) oxidation

    $I^-$ (to $I_2$), increase in oxidation number / loss of electron(s);

    reduction

    IO$_3^-$ (to $I_2$), decrease in oxidation number / gain of electron(s);  

(b) object to be plated is negative electrode/cathode;

    pure copper is positive electrode/anode;

    Accept inert electrode

(both electrodes in) solution/electrolyte of copper(II) sulfate/chloride/ CuSO$_4$ / CuCl$_2$ ;

Accept an annotated diagram showing all the information for the first [3] marks

    Cu$^{2+}$ + 2e$^-$ $\rightarrow$ Cu;  

[4]

7.  (a) NaOH is a strong base / NH₃ is a weak base;
NaOH completely dissociates/ionizes;
NH₃ partially dissociates/ionizes;

pH 14 has high [OH⁻] / low [H⁺] / pH 12 has lower [OH⁻] / higher [H⁺];

NaOH → Na⁺ + OH⁻;
NH₃ + H₂O ⇄ NH₄⁺ + OH⁻; (⇌ required) \{5 \text{ max}\}

(b) (i) \(\text{NaOH} + \text{HNO}_3 \rightarrow \text{NaNO}_3 + \text{H}_2\text{O}\); \{1\}

(ii) 1 pH / pOH unit represents a 10 fold change in concentration;

So if a 1.0 mol dm⁻³ NaOH solution has a pH of 14
then a 0.10 mol dm⁻³ solution will have a pH of 13;

Units needed for the mark.

Award [2] for correct final answer.

(iii) 18.0 cm³;

\[
\frac{0.10 \times 20.0}{18.0} = 0.11 \text{ mol dm}^{-3}; \{2\}
\]
 Allow ECF from an incorrect value of concentration in part (ii).

(iv) 18.0 cm³; \{1\}

(c) conductivity:

nitric acid will contain more ions and have a higher conductivity / ethanoic acid
will have fewer ions and have a lower conductivity;

rate of reaction with metal / carbonate / hydrogencarbonate;
nitric acid will react more rapidly / produce bubbles faster / ethanoic acid will react
less rapidly / produce bubbles more slowly;

reaction with alkali;
temperature change will be less for ethanoic acid; \{4 \text{ max}\}

Accept any two methods and explanations from above.
(d) (i) HCl / X is strong and CH₃COOH / Z is weak; 
HCl / X is fully dissociated and CH₃COOH is slightly dissociated; 
[H⁺] is greater in HCl/X than in CH₃COOH/Z; 
[2 max]
*Any two for [1] each.*

(ii) a factor of 100; 
[1]

Q# 27/ IB Chem/2006/s/tz1/Paper 2 Section B/Standard Level/

8. (a) HCl/H₂SO₄/HNO₃ / any strong acid; 
CH₃COOH/H₂CO₃ / any weak acid; 
Measure pH – the strong acid has the lower pH; 
*Accept universal indicator and two correct colours.* 
Measure (electrical) conductivity – this is greater for the stronger acid; 
Add magnesium/carbonate – more gas bubbles with the stronger acid / Mg or carbonate 
would disappear faster with stronger acid; 
[5]

(b) amphoteric/amphiprotic; 
as an acid: HCO₃⁻ + H₂O → H₂CO₃⁻ + OH⁻; H₂CO₃⁻ → H⁺ + CO₃²⁻; 
as a base: HCO₃⁻ + H₂O → OH⁻ + H₂CO₃⁻ / HCO₃⁻ + H⁺ → H₂CO₃; *accept H₂O + CO₂.* 
[3]

(c) vinegar and factor of 10⁶; 
[1]

Q# 28/ IB Chem/2005/w/tz0/Paper 2 Section B/Standard Level/

(b) (i) X; 
[1]

(ii) greater in Y/smaller in Z; 
by a factor of 10; 
[2]

(iii) Y > Z > X; 
most ions/greatest concentration of ions in Y/OWTTE; 
[2]

Q# 29/ IB Chem/2004/w/TZ0/Paper 2 Section A/Standard Level/

4. (a) (pH =) 1; 
a tenfold increase in the hydrogen ion / H⁺ concentration; 
*Accept calculation/strong acid / completely ionized (for reason).* 
[2]

(b) (pH) > 2 and < 7; 
ethanoic acid is a) weak acid / partially ionized in solution; 
*Accept pH > 1 (ignore reference to < 7) / calculation.* 
[2]

Q# 30/ IB Chem/2003/s/tz1/Paper 2 Section B/Standard Level/

7. (a) strong acid completely dissociated / ionized; 
weak acid only partially dissociated / ionized; 
HCl(aq) → H⁺(aq) + Cl⁻(aq); 
CH₃COOH(aq) ⇌ CH₃COO⁻(aq) + H⁺(aq); 
*Insist on both arrows as shown, state symbols not needed.* 
*Also accept H₂O(I) and H₂O⁺(aq) in equations.* 
[4]

(b) (i) bubbling / effervescence / dissolving of CaCO₃ / gas given off *(do not accept CO₂ produced)*; 
more vigorous reaction with HCl / OWTTE; 
[2]
(ii) \[ 2\text{HCl(aq)} + \text{CaCO}_3(s) \rightarrow \text{CaCl}_2(aq) + \text{CO}_2(g) + \text{H}_2\text{O(l)}; \]


(iii) amount of \( \text{CaCO}_3 \) = \( \frac{1.25}{100.09} \) = 0.0125 mol (no penalty for use of 100);

amount of \( \text{HCl} \) = 2 \times 0.0125 = 0.0250 mol (allow ECF);

volume of \( \text{HCl} \) = 0.0167 dm\(^3\) / 16.7 cm\(^3\) (allow ECF);  

(iv) 1:1 ratio of \( \text{CaCO}_3 \) to \( \text{CO}_2 \) / use 0.0125 moles \( \text{CO}_2 \) (allow ECF);

\( (0.0125 \times 22.4) = 0.28 \text{ dm}^3 / 280 \text{ cm}^3 / 2.8 \times 10^{-4} \text{ m}^3 \) (allow ECF);

Accept calculation using \( pV=nRT \).

(c) (i) 0.1 (mol dm\(^{-3}\)) (units not needed but penalize if incorrect);  

(ii) to 0.01 / decreases by factor of 10 / goes down by 0.09;  

(iii) 25 cm\(^3\);  

Q#31/ IB Chem/2002/w tz0/Paper 2 Section B/Standard Level/

5. (a) strong acid is fully ionised / dissociated (in solution);

\( \text{HCl(aq)} \rightarrow \text{H}^+(aq) + \text{Cl}^- (aq); \)

weak acid is only partly ionised / dissociated (in solution);

\( \text{H}_2\text{CO}_3(aq) \rightleftharpoons 2\text{H}^+(aq) + \text{CO}_3^{2-}(aq) / \text{H}_2\text{CO}_3(aq) \rightleftharpoons \text{H}^+(aq) + \text{HCO}_3^-(aq); \)

\rightarrow needed in first equation, \( \equiv \) needed in second equation, state symbols not required, accept equations including water as reagent.

(b) e.g. universal indicator;

\( \text{HCl} = \text{red} \)

\( \text{H}_2\text{CO}_3 = \text{yellow/orange} \);

electrical conductivity;

\( \text{HCl} = \text{high} \)

\( \text{H}_2\text{CO}_3 = \text{low} \);

reaction with metal /

\( \text{HCl} = \text{vigorous} \)

metal carbonate;

\( \text{H}_2\text{CO}_3 = \text{slow}; \)

[4 max]

Any two of the above, [1] for test and [1] for correct answer for both acids. Accept other suitable answers.

(c) correct ratio e.g. 10000:1 / \( 10^4:1 \) / 0.1:0.00001 / 1:0.0001 / \( 10^{-7}:10^{-5} \);

\( \text{HCl}:\text{H}_2\text{CO}_3 \);

(correct number ratio = [1], correct way round clearly stated).

(d) (i) \( \text{HCO}_3^- \) and \( \text{H}_2\text{CO}_3 \) base

conjugate acid;

\( \text{HCl} \) and \( \text{Cl}^- \) acid

conjugate base;  

[2]

(ii) Bronsted-Lowry;  

[1]
(e) strong base = barium hydroxide / any group 1 hydroxide; weak base = ammonia / aminoethane / magnesium hydroxide; 

Accept other suitable examples and accept correct formulas. [2]

(f) Accept any correctly balanced equation with \( \text{H}_2\text{CO}_3 \) and a base identified in (e).

e.g. \( \text{H}_2\text{CO}_3 + \text{Ba(OH)}_2 \rightarrow \text{BaCO}_3 + 2\text{H}_2\text{O} \)

or \( \text{H}_2\text{CO}_3 + 2\text{NH}_3 \rightarrow (\text{NH}_4)_2\text{CO}_3 \) [2]

All formulas correct = [1]; correct balancing = [1]. State symbols not necessary.

(g) (i) basic / alkaline;

(ii) neutralisation;

(iii) too strong / damages skin / corrosive / OWTTE; [3]

Q# 32/ IB Chem/2002/sTZ1/Paper 2 Section A/Standard Level/

2. (a) Both are proton acceptors. [1]

(b) (i) sodium hydroxide, more ions / more dissociated [1]

(ii) greater / 12–14 [1];

more \( \text{OH}^- \) / less \( \text{H}^+ \) [1].

Second mark can only be awarded if the first mark has been achieved. [2]

(c) \( \text{NH}_3 + \text{H}_2\text{O} \rightleftharpoons \text{NH}_4^+ + \text{OH}^- \) [1];

acid base [1]; [2]

Q# 33/ IB Chem/2001sQ3

(c) Fluorine / \( \text{F}_2 \) [1]

\( \text{F}_2 \) gains electrons / \( \text{F}_2 \) is reduced / oxidation number decreases [1]

or

Ca loses electrons / Ca oxidation number increases [1] [2 max]

Q# 34/ IB Chem/2001/w tz0/Paper 2 Section B/Standard Level/
7. (a) pH of 7 will be NaCl; NaCl is a neutral salt
pH of 13 is NaOH; it is a strong base (fully ionised). No mark for ‘high pH’
pH of 1 is HCl; it is a strong acid (fully ionised). No mark for ‘low pH’
pH of about 11 for NH₃; a weak base (partially hydrolysed, less OH⁻)
pH of about 3 will be CH₃COOH; a weak acid (partially ionised, less H⁺)
(for NH₃ accept 13 < pH > 7; for CH₃COOH 7 < pH > 1)

(b) (i) \( \text{HCO}_3^- + \text{OH}^- \rightarrow \text{H}_2\text{O} + \text{CO}_3^{2-} \) (states not required; accept molecular equation)
The reaction decreases [OH⁻] in the solution and the pH decreases.

(ii) \( \text{HCO}_3^- + \text{H}_3\text{O}^+ \rightarrow \text{H}_2\text{O} + \text{H}_2\text{CO}_3 \) (accept \( \text{H}_2\text{O} + \text{CO}_2 \) in place of \( \text{H}_2\text{CO}_3 \))
(States not required. Accept \( \text{H}^+ \) in place of \( \text{H}_2\text{O}^+ \).)
The reaction decreases [H⁺] in the solution and the pH increases.

(c) in (b) (i): \( \text{HCO}_3^- \): proton donor, acid; \( \text{OH}^- \): proton acceptor, base
in (b) (ii): \( \text{HCO}_3^- \): proton acceptor, base; \( \text{H}_3\text{O}^+ \): proton acceptor, acid

(d) (i) Strong acid: Acid 1 / acid with high conductivity / Weak acid: Acid 2 / acid with lower conductivity.
Strong acid is (almost) fully / 100% dissociated as [acid] increases, the number of ions increases, and so does the conductivity.
Weak acid is only partially dissociated producing fewer ions in solution.
As [acid] increases, the number of ions increases initially until an equilibrium is established.
The concentration of ions becomes constant and the conductivity remains constant as well.

(ii) Both reactions produce gas / \( \text{H}_2 \)
The acid that reacts more quickly / producing more bubbles is the strong acid (the other is the weak acid).
(If gas produced is implicit in the second answer, award [2].)

(iii) Same volume (10.0 cm³) required.

Q# 35/ IB Chem/2001/s/TZ1/Paper 2 Section A/Standard Level/
2. (a) \([\text{OH}^-] > [\text{H}^+] / \text{pH} > 7 / \text{more OH}^- \)
(Accept \( \text{OH}^- \) ions formed)

(b) Base \[1\]
Accepting a proton / (\( \text{H}^+ \)) / hydrogen ion \[1\] \[2\] max

(c) \( \text{HCO}_3^- \) / hydrogen carbonate / bicarbonate \[1\]
Q# 36/ IB Chem/2000/w/TZ0/Paper 2 Section A/Standard Level/

1. (a)  
   (i)  \( \text{pH} = 2.6 \) (accept 2.5 to 2.7)  
   \[ [H^+] = 0.01 \text{ mol dm}^{-3} \] (accept mol/l or M)  
   \( \text{(No mark without units.)} \)  
   (iii)  \( 15.3 \text{ cm}^3 - 15.6 \text{ cm}^3 \) (units not needed)  
   (iv)  \( 0.016 \text{ mol dm}^{-3} \) (ECF from (iii))  
   
(b)  
   (i)  A strong acid is (almost) fully dissociated (ionised) whereas a weak acid is partly dissociated.  
   (ii)  amount (moles) = \( 0.5 \times 0.5 = 0.250 \) mol (units not needed)  
       \( m = 0.25 \times 60 = 15 \) g (units needed)  

Q# 37/ IB Chem/2000/s/TZ1/Paper 2 Section A/Standard Level/

1. (a)  
   \[ K_c = \frac{[H^+][CN^-]}{[HCN]} \]  
   \( \text{(Award 1 mark for products as numerator reactants as denominator; award 1 mark for correct symbols.)} \)  
   
(b)  
   HCN > CH₃COOH > HF > HCl  
   
(c)  
   HCl < HF < CH₃COOH < HCN  
   
(d)  
   H⁺ / H₂O⁺, CH₃COO⁻, CH₃COOH  
   
(e)  
   Fluoride, \( F^- \)  
   
(f)  
   Measure conductivity  
   greater for HCl  
   
\( \text{OR} \)  
   Chemical reaction  
   e.g. add magnesium metal to each solution  
   more vigorous reaction with HCl  

Q# 38/ IB Chem/1999/w/TZ0/Paper 2 Section A/Standard Level/

3. (a)  
   A weak acid is only slightly dissociated into H⁺ ions and its anions in aqueous solution.  
   
(b)  
   \[ \text{CH₃COOH} + \text{H₂O} \rightarrow \text{H₃O}^+ + \text{CH₃COO}^- \]  
   acid base acid base  
   
(c)  
   \[ \text{H} - \text{C} - \text{C} = \text{O}^- \]  
   Allow resonance canonical forms
Q# 39/ IB Chem/1999/s/tz1/Paper 2 Section B/Standard Level/

6. (a) **three** correctly-balanced equations from:
   - appropriate metal/acid $\rightarrow$ $H_2$;
   - MO and acid;
   - MOH and acid;
   - M-carbonate and acid;

   **one each**

   if $H-X$ used, maximum [2 marks]

   Accept any reasonable chemical reaction for acid [3 marks]

(b) $H^+$ donor (acid) **and** $H^+$ acceptor (base)

   $NH_3 + H_2O \rightarrow NH_4^+ + OH^-$

   ($NH_3$ accepting proton [1 mark]; balanced correctly [1 mark])

   pH paper will turn blue/pH value of 10–12 [2 mark]

(c)

<table>
<thead>
<tr>
<th>acid</th>
<th>conjugate base</th>
<th>base</th>
<th>conjugate acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) $H_2SO_4$</td>
<td>$HSO_4^-$</td>
<td>$HNO_3$</td>
<td>$H_2NO_3^-$</td>
</tr>
<tr>
<td>(ii) $H_2O$</td>
<td>$OH^-$</td>
<td>$CH_3CH_2NH_2$</td>
<td>$CH_3CH_2NH_3^+$</td>
</tr>
</tbody>
</table>

acid/conjugate base and base/conjugate acid [1 mark] each [2 marks]

(d) $H_2SO_4$ is stronger than $HNO_3$

   Some evidence of reasoning e.g. $H_2SO_4$ gives proton to $HNO_3$ in equation (i) [1 mark]

(e) Strong acid is completely dissociated/ionised, weak acid only partially dissociated/ionised.

   Test solutions of equal concentration/equimolar solutions

   Strong acid gives lower pH value/higher conductivity [1 mark]

   **OR**

   Weak acid gives higher pH value/lower conductivity [1 mark]

   **OR**

   Strong acid gives faster reaction with carbonate/suitable metal [1 mark]

(f) (i) **A** is stronger acid

   Difference of 1 pH unit= 10 fold difference in acidity

   Therefore A is $10 \times 10 \times 10 \times 10 = 10000$ times more acidic

   award BOTH marks if correct value given [1 mark]

   (ii) add a base/alkali, add water/dilute

   [1 mark] each [2 marks]