**IB Chemistry – SL**

**Topic 8 Questions**

**1.** An aqueous solution of which of the following reacts with magnesium metal?

A. Ammonia

B. Hydrogen chloride

C. Potassium hydroxide

D. Sodium hydrogencarbonate

**2.** Which of the following is/are formed when a metal oxide reacts with a dilute acid?

I. A metal salt

II. Water

III. Hydrogen gas

A. I only B. I and II only

C. II and III only D. I, II and III

**3.** Four aqueous solutions, I, II, III and IV, are listed below.

I. 0.100 mol dm–3 HCl

II. 0.010 mol dm–3 HCl

III. 0.100 mol dm–3 NaOH

IV. 0.010 mol dm–3 NaOH

What is the correct order of **increasing** pH of these solutions?

A. I, II, III, IV

B. I, II, IV, III

C. II, I, III, IV

D. II, I, IV, III

**4.** Which substance can be dissolved in water to give a 0.1 mol dm–3 solution with a high pH and a high electrical conductivity?

A. HCl

B. NaCl

C. NH3

D. NaOH

**5.** The pH of a solution is 2. If its pH is increased to 6, how many times greater is the [H+] of the original solution?

A. 3

B. 4

C. 1000

D. 10 000

**6.** The pH of solution **X** is 1 and that of **Y** is 2. Which statement is correct about the hydrogen ion concentrations in the two solutions?

A. [H+] in **X** is half that in **Y**.

B. [H+] in **X** is twice that in **Y**.

C. [H+] in **X** is one tenth of that in **Y**.

D. [H+] in **X** is ten times that in **Y**.

**7.** Lime was added to a sample of soil and the pH changed from 4 to 6. What was the corresponding change in the hydrogen ion concentration?

A. increased by a factor of 2

B. increased by a factor of 100

C. decreased by a factor of 2

D. decreased by a factor of 100

**8.** When the following 1.0 mol dm–3 solutions are listed in increasing order of pH (lowest first), what is the correct order?

A. HNO3  H2CO3  NH3  Ba(OH)2

B. NH3  Ba(OH)2  H2CO3  HNO3

C. Ba(OH)2  H2 CO3  NH3  HNO3

D. HNO3  H2CO3  Ba(OH)2  NH3

**9.** Which change in [H+] causes the biggest increase in pH?

A. A change in [H+(aq)] from 1×10–3 to 1×10–2 mol dm–3

B. A change in [H+(aq)] from 1×10–3 to 1×10–4 mol dm–3

C. A change in [H+(aq)] from 1×10–4 to 1×10–2 mol dm–3

D. A change in [H+(aq)] from 1×10–4 to 1×10–6 mol dm–3

**10.** Which methods can distinguish between solutions of a strong monoprotic acid and a weak monoprotic acid of the same concentration?

I. Add magnesium to each solution and measure the rate of the formation of gas bubbles.

II. Add aqueous sodium hydroxide to each solution and measure the temperature change.

III. Use each solution in a circuit with a battery and lamp and see how bright the lamp glows.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

**11.** Which species are a conjugate pair according to the Brønsted-Lowry theory?

A. CH3COOH and CH3CHO

B. NH3 and BF3

C. H2NO3+ and NO3–

D. H2SO4 and HSO4–

**12.** Which is **not** a strong acid?

A. Nitric acid B. Sulfuric acid

C. Carbonic acid D. Hydrochloric acid

**13.** Lime is added to a lake to neutralize the effects of acid rain. The pH value of the lake water rises from 4 to 7. What is the change in concentration of H+ ions in the lake water?

A. An increase by a factor of 3

B. An increase by a factor of 1000

C. A decrease by a factor of 3

D. A decrease by a factor of 1000

**14.** Which is a Brønsted-Lowry acid-base pair?

A. H2O and O2–

B. CH3COOH and CH3COO–

C. NH4+ and NH2–

D. H2SO4 and SO42–

**15.** Solutions of hydrochloric acid (HCl(aq)) and ethanoic acid (CH3COOH(aq)) of the same concentration reacted completely with 5.0 g of calcium carbonate in separate containers. Which statement is correct?

A. CH3COOH(aq) reacted slower because it has a lower pH than HCl(aq).

B. A smaller volume of CO2(g) was produced with CH3COOH(aq) than with HCl(aq).

C. A greater volume of CO2(g) was produced with CH3COOH(aq) than with HCl(aq).

D. The same volume of CO2(g) was produced with both CH3COOH(aq) and HCl(aq).

**17.** Which acids are strong?

I. HCl(aq)

II. HNO3(aq)

III. H2SO4(aq)

A. I and II only B. I and III only

C. II and III only D. I, II and III

**18.** The pH of a solution changes from pH = 1 to pH = 3. What happens to the [H+] during this pH change?

A. It increases by a factor of 100.

B. It decreases by a factor of 100.

C. It increases by a factor of 1000.

D. It decreases by a factor of 1000.

**19.** What is the conjugate base of the HSO4–(aq) ion?

A. H2SO4(aq)

B. SO42–(aq)

C. H2O(l)

D. H3O+(aq)

**20.** Which species can act as a Lewis acid?

A. BF3

B. OH–

C. H2O

D. NH3

**21.** Which substance, when dissolved in water, to give a 0.1 mol dm–3 solution, has the highest pH?

A. HCl

B. NaCl

C. NH3

D. NaOH

**22.** Which methods will distinguish between equimolar solutions of a strong base and a strong acid?

I. Add magnesium to each solution and look for the formation of gas bubbles.

II. Add aqueous sodium hydroxide to each solution and measure the temperature change.

III. Use each solution in a circuit with a battery and lamp and see how bright the lamp glows.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

**23.** (a) Aqueous XO43– ions form a precipitate with aqueous silver ions, Ag+. Write a balanced equation for the reaction, including state symbols.

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(2)

(b) When 41.18 cm3 of a solution of aqueous silver ions with a concentration of 0.2040 mol dm–3 is added to an excess solution of XO43– ions, 1.172 g of the precipitate is formed.

(i) Calculate the amount (in moles) of Ag+ ions used in the reaction.

(1)

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(ii) Calculate the amount (in moles) of the precipitate formed.

(1)

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(iii) Calculate the molar mass of the precipitate.

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(2)

(iv) Determine the relative atomic mass of X and identify the element.

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(2)

(Total 8 marks)

**24.** (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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(2)

(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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(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.

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(2)

(Total 7 marks)

**25.** 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.

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(Total 4 marks)

**26.** (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.

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(2)

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

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(2)

(iii) Determine the volume of 1.50 mol dm–3 hydrochloric acid that would react with exactly 1.25 g of calcium carbonate.

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(3)

(iv) Calculate the volume of carbon dioxide, measured at 273 K and 1.01×105 Pa, which would be produced when 1.25 g of calcium carbonate reacts completely with the hydrochloric acid.

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(2)

(Total 9 marks)

**27.** The pH values of solutions of three organic acids of the same concentration were measured.

acid X pH = 5

acid Y pH = 2

acid Z pH = 3

(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)

(Total 5 marks)

**28.** The equilibrium reached when ethanoic acid is added to water can be represented by the following equation:

CH3COOH(l) + H2O(l)  CH3COO–(aq)+H3O+(aq)

Define the terms Brønsted-Lowry acid and Lewis base, and identify two examples of each of these species in the equation.

(Total 4 marks)

**29.** 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.

(Total 5 marks)

**30.** 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.

(Total 1 mark)

**31.** Define the terms *Brønsted-Lowry acid* and *Lewis acid*. For each type of acid, identify one example other than water and write an equation to illustrate the definition.

(Total 5 marks)

**32.** The pH values of three acidic solutions, X, Y and Z, are shown in the following table:

|  |  |  |
| --- | --- | --- |
| Solution | Acid | pH |
| X | HCl(aq) | 2 |
| Y | HCl(aq) | 4 |
| Z | CH3COOH(aq) | 4 |

(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)

(Total 3 marks)

**33.** 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.

(Total 4 marks)

**34.** Propanoic acid is classified as a weak acid.

(a) State the meaning of the term *weak acid*.

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(1)

(b) State, giving a reason in each case, **two** methods other than measuring pH, that could be used to distinguish between 0.100 mol dm–3 propanoic acid and 0.100 mol dm–3 nitric acid.

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(2)

(Total 3 marks)

**35.** State an equation for the reaction of propanoic acid with water. Identify **one** conjugate *Brønsted-Lowry* pair.

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(Total 2 marks)

**IB Chemistry – SL**

**Topic 8 Answers**

**1.** B

**2.** B

**3.** B

**4.** D

**5.** D

**6.** D

**7.** D

**8.** A

**9.** D

**10.** D

**11.** D

**12.** C

**13.** D

**14.** B

**15.** D

**16.** D

**17.** D

**18.** B

**19.** B

**20.** A

**21.** D

**22.** A

**23.** (a) 3Ag+(aq) + XO43–(aq) → Ag3XO4(s);  
states; 2

**[1]** for balanced equation and **[1]** for states.

(b) (i) nAg+ = cV = 0.2040 mol dm–3×0.04118 dm3  
 = 0.008401/8.401×10–3 mol (–*1 SF*) 1  
*Ignore units even if wrong, do not award mark unless 4 sig fig.*

(ii)  = nAg+ = ×0.008401 mol  
 = 0.002800/2.800×10–3 mol 1

*ECF from (a) and (b)(i)*

(iii) 0.002800 mol weighs 1.172 g  
1 mol weighs  = 418.6 g mol–1 2

418.6;  
Accept answer in range 418 to 419.  
No penalty for too many sig figs.  
ECF from (b) (ii)  
g mol–1  
Do not accept g.

(iv) (3×107.87) + *x +* 4 (16.0) = 418.6  
therefore, *x* = 30.99 *(accept 31.0/31)*;  
P/phosphorous; 2

[8]

**24.** (a) (i) 0.0010 / 1.0×103 (mol dm3);

pH = 3; 2

(ii) HCl: strong acid/fully dissociated;

CH3COOH : weak acid/partially dissociated;

HCl less concentrated/CH3COOH more concentrated;

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

(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; 2

*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.*

[7]

**25.** strong acid completely dissociated/ionized;  
weak acid only partially dissociated/ionized;

HCl(aq)  H+(aq) + Cl+(aq);  
CH3COOH(aq)  CH3COO–(aq) + H+(aq); 4

Insist on both arrows as shown, state symbols not needed.  
Also accept H2O(1) and H3O+(aq) in equations

[4]

**26.** (i) bubbling/effervescence/dissolving of CaCO3/gas given off   
(*do not accept* CO2 *produced*);  
more vigorous reaction with HCl/*OWTTE*; 2

(ii) 2HCl(aq) + CaCO3(s)  CaCl2(aq) + CO2(g) + H2O(1); 2

**[1]** for correct formulas, **[1]** for balanced, state symbols not essential.

(iii) amount of CaCO3 =  (*no penalty for use of 100*);  
amount of HCl = 2×0.0125 = 0.0250 mol (*allow ECF*);  
volume of HCl = 0.0167 dm3/16.7 cm3 (*allow ECF*); 3

(iv) 1:1 ratio of CaCO3 to CO2 /use 0.0125 moles CO2 (*allow ECF*);  
(0.0125×22.4) = 0.28 dm3/280 cm3/2.8×10–4 m3 (*allow ECF*); 1

Accept calculation using pV=nRT.

[9]

**27.** (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

[5]

**28.** *Brønsted-Lowry acid*

proton donor/*OWTTE*;

CH3COOH and H3O+;

*Lewis base*

electron pair donor/*OWTTE*;

H2O and CH3COO; 4

[4]

**29.** 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]

**30.** vinegar and factor of 105;

[1]

**31.** *Brønsted-Lowry acid*  
a proton donor;

*Lewis acid*  
electron pair acceptor;

*Brønsted-Lowry acid*

Any suitable equation;

Lewis acid  BF3/AlCl3/transition metal ions that form complex ion  
with ligands;

For example  
BF3 + NH3  BF3NH3/Cu2+ + 4NH3  [Cu(NH3)4]2+/AlCl3 + Cl  ; 5

Or any suitable equation.

[5]

**32.** (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

Any two for **[1]** each.

(ii) a factor of 100; 1

[3]

**33.** 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

Accept any two methods and explanations from above.

[4]

**34.** (a) an acid that partially dissociates/ionizes/doesn’t fully dissociate/ionize; 1

(b) conductivity - propanoic acid will be lower because lower ion concentration  
/less dissociated;

reaction with metal/metal carbonate/metal hydrogencarbonate - propanoic  
acid will react slower/less vigorously because lower [H+]/less dissociated;

reaction with alkali - temperature change will be less for propanoic acid  
because lower [H+]/less dissociated; 2

Award **[1]** mark each for two.

[3]

**35.** CH3CH2COOH + H2O  CH3CH2COO + H3O+/CH3CH2COOH   
CH3CH2COO + H+;

 required for mark.

CH3CH2COOH and CH3CH2COO/H3O+ and H2O; 2

[2]