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Chemistry

1999 TEE Solutions*

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The Curriculum Council
27 Waters Drive
Osborne Park 6017

*These solutions are not a marking key. They are a guide to the possible answers at a depth that might be expected of Year 12 students. It is unlikely that all possible answers to the questions are covered in these solutions.

 STAWA appreciates the support of the Curriculum Council, which provided the marker's guides used a basis for these solutions.

TEE Chemistry 1999 Solutions

Part 1

1. c	6. d	11. a	16. c	21. d	26. d
2. c	7. d	12. b	17. d	22. c	27. b
3. a	8. c	13. a	18. c	23. d	28. c
4. d	9. a	14. b	19. c	24. c	29. a
5. a	10. d	15. d	20. a	25. d	30. b

For Parts 2 and 3, the answers have been prepared according to the following guidelines:

- We have tried to prepare a set of model answers. As such we have not attempted to cover all possibilities and thus clutter the document with qualifications. The aim has been to produce one set of answers that a good student could aspire to.
- In most cases, only one answer has been given even when other answers are correct.
- In the calculations, a method of working has been used which emphasises reasoning. The answers given here are modelled on approaches adopted by students where their schools have been conspicuously successful in public examinations.

Part 2

1. (a) $Pb^{2+}(aq) + 2\,I^-(aq) \rightarrow PbI_2(s)$
   Yellow (or white or cream) precipitate forms.

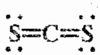
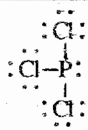
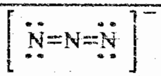
   (b) $NH_4^+(aq) + OH^-(aq) \rightarrow NH_3(aq) + H_2O(l)$
   Pungent odour is produced.

   (c) $Al(OH)_3(s) + OH^-(aq) \rightarrow [Al(OH)_4]^-(aq)$
   White solid dissolves to give a colourless solution.

   (d) $K_2CO_3(s) + 2\,H^+(aq) \rightarrow 2\,K^+(aq) + CO_2(g) + H_2O(l)$
   White solid dissolves to give a colourless solution and a colourless, odourless gas is produced.

2. (a) $1s^2\ 2s^22p^6$
   (b) $1s^2\ 2s^22p^6\ 3s^2$

3.

Species	Structural formula	Shape
carbon disulfide CS_2		linear
phosphorus trichloride PCl_3		pyramidal
azide ion N_3^-		linear

4. (a) Acetic acid, since in solution it exists mainly as CH_3COOH molecules, while the other solutions contain completely ionised or dissociated species.

(b) Sodium hydroxide, since it is the only one of the substances which produces OH^- ions in water and therefore a high pH.

(c) Sulfuric acid, since it dissociates completely into H^+ and HSO_4^- as well as partly into H^+ and SO_4^{2-}.

5. Carbon dioxide is slightly soluble in water, producing an acidic solution of carbonic acid:

$$CO_2 + H_2O \rightarrow HCO_3^- + H^+$$

The solubility of carbon dioxide in water decreases as the temperature increases, so as the solution is boiled, the gas begins to leaves the solution and the solution becomes less acidic (the pH increases). When the solution is cooled, the carbon dioxide gradually dissolves back into the solution, causing the pH to drop again.

6. (a) Add NaCl solution.
With $AgNO_3$, a white precipitate would form: $Ag^+ (aq) + Cl^- (aq) \rightarrow AgCl (s)$
With $NaNO_3$, there would be no visible reaction.

(b) Pass the gases through limewater.
With Ar, there would be no visible reaction.
With CO_2, the limewater would become milky:

$$CO_2 (g) + Ca^{2+} (aq) + 2\ OH^- (aq) \rightarrow CaCO_3 (s) + H_2O (l)$$

7. $[Ag(NH_3)_2]^+$, $[Cu(NH_3)_4]^{2+}$ or $[Zn(NH_3)_4]^{2+}$ etc.

Al_2O_3	(alumina)
2-propanol etc.	(any secondary alcohol)
$CH_3CH_2NH_2$	(ethanamine)
$Ca(OH)_2$	(calcium hydroxide)
Cu^+	(copper(I) ion)
NH_3	(ammonia)
$H_2C_2O_4$	(oxalic acid)

Note: there are many different possible answers for question 7.

8. Oxidation: $[CH_3OH + H_2O \rightarrow CO_2 + 6\ H^+ + 6\ e^-]$ × 5
Reduction: $[MnO_4^- + 8\ H^+ + 5\ e^- \rightarrow Mn^{2+} + 4\ H_2O]$ × 6

Overall: $6\ MnO_4^- + 5\ CH_3OH + 18\ H^+ \rightarrow 6\ Mn^{2+} + 5\ CO_2 + 19\ H_2O$

9.

$CH_3-CH_2-CH_2-CH_2OH$	1-butanol	1°
$\begin{array}{c}\quad\quad\quad OH\\ \quad\quad\quad \vert \\ CH_3-CH_2-CH-CH_3\end{array}$	2-butanol	2°
$\begin{array}{c}\quad CH_3\\ \quad \vert \\ CH_2-CH-CH_2OH\end{array}$	methyl-1-propanol	1°
$\begin{array}{c}\quad CH_3\\ \quad \vert \\ CH_2-CH-CH_3\\ \quad \vert \\ \quad OH\end{array}$	methyl-2-propanol	3°

10. (a) $Ni^{2+} + 2\,e^- \rightarrow Ni$

(b) $\rightarrow$ (i.e. from the Zn electrode to the Ni electrode)

(c) $0.76 - 0.26 = 0.50$ V

11.

$CH_3CH_2CH_2CH_2CH_2CH_3$	4
$CH_3CH_2CH_2COOH$	1
$CH_3CH_2CH_2CH(CH_3)_2$	5
$CH_3CH_2CH_2CH_2CH_2OH$	2
$CH_3CH_2CH_2CH_2CHO$	3

Part 3

1. (a) V at STP $= \frac{P_1V_1}{T_1} \times \frac{T_2}{P_2}$

$$= \frac{0.0026 \times 0.460}{273.1 + 100} \times \frac{273.1}{1}$$

$= 8.754 \times 10^{-4}$ L

n $= \frac{8.754 \times 10^{-4}}{22.41}$

$= 3.906 \times 10^{-5}$ mol

M $= \frac{0.0033}{3.906 \times 10^{-5}}$

$= 84.5$ g mol^{-1}

(b) $M(CH_2O) = 12.01 + 2 \times 1.008 + 16.00 = 30.026$ g mol^{-1}

$84.5/30.026 = 2.8 \approx 3$

$\therefore$ Molecular formula is $C_3H_6O_3$

(c) an alcohol

(d) $CH_3-CH(OH)-COOH$ or $CH_2(OH)-CH_2-COOH$

2. (a) $V(Cl_2$ at STP$) = \frac{P_1V_1}{T_1} \times \frac{T_2}{P_2}$

$$= \frac{1.00 \times 500}{273.1 + 10} \times \frac{273.1}{1}$$

$= 482.3$ L

$n(Cl_2) = \frac{482.3}{22.41}$

$= 21.5$ mol

(b) $n(e^-) = 2 \times n(Cl_2)$

$= 43.0$ mol

q $= 43.0 \times 9.65 \times 10^4$

$= 4.15 \times 10^6$ C

I $= \frac{4.15 \times 10^6}{60 \times 60 \times 24.0}$

$= 48.1$ A

(c) $n(OH^-) = 2 \times n(Cl_2) = 43.0$ mol $[OH^-] = \frac{43.0}{1000} = 4.30 \times 10^{-2}$ mol L^{-1}

(d) $n(Cl^-$ reacted) $= 2 \times n(Cl_2) = 43.0$ mol

$n(HCl$ needed) $= n(Cl^-) = 43.0$ mol

$V(HCl$ at 25°C) $= 43.0 \times 24.47$

$= 1.05 \times 10^3$ L

(e) $I = 48.1 \times 100/90 = 53.4$ A

3\. (a) (i) $Ca(OH)_2 \rightarrow CaO + H_2O$ (ii) $CaCO_3 \rightarrow CaO + CO_2$

(b) $m(CaO) = 45.3$ mg

$M(CaO) = 40.08 + 16.00$

$= 56.08 \text{ g mol}^{-1}$

(i) $m(H_2O$ released) $= 52.7 - 48.5$

$= 4.2$ mg

$n(H_2O$ released) $= \dfrac{4.2 \times 10^{-3}}{18.016}$

$= 2.331 \times 10^{-4}$ mol

n(CaO which absorbed water) $= n(H_2O)$

$= 2.331 \times 10^{-4}$ mol

m(CaO which absorbed water) $= 2.331 \times 10^{-4} \times 56.08$

$= 1.307 \times 10^{-2}$ g

% of CaO which absorbed water $= \dfrac{1.307 \times 10^{-2}}{45.3 \times 10^{-3}} \times 100$

$= 28.9\%$

(ii) $m(CO_2$ released) $= 48.5 - 45.3$

$= 3.2$ mg

$n(CO_2$ released) $= \dfrac{3.2 \times 10^{-3}}{44.01}$

$= 7.271 \times 10^{-5}$ mol

n(CaO which absorbed CO_2) $= n(CO_2)$

$= 7.271 \times 10^{-5}$ mol

m(CaO which absorbed CO_2) $= 7.271 \times 10^{-5} \times 56.08$

$= 4.078 \times 10^{-3}$ g

% of CaO which absorbed CO_2 $= \dfrac{4.078 \times 10^{-3}}{45.3 \times 10^{-3}} \times 100$

$= 9.00\%$

4. (a) 2.5 mol

(b) $n(MnO_4^-)$ $= 0.02023 \times 0.03008$
$= 6.085 \times 10^{-4}$ mol

$n(Na_2SO_3)$ $= 2.5 \times n(MnO_4^-)$
$= 2.5 \times 6.085 \times 10^{-4}$
$= 1.52 \times 10^{-3}$ mol

(c) $M(Na_2SO_3)$ $= 2 \times 22.99 + 32.06 + 3 \times 16.00$
$= 126.04$ g mol^{-1}

$m(Na_2SO_3)$ $= 1.52 \times 10^{-3} \times 126.04$
$= 0.1917$ g

0.1917 g in 1.00 kg = 192 ppm

(d) To ensure all the sulfite is converted to sulfur dioxide.

(e) Colourless to pink.

5. (a) $n(\text{total } H_4Y)$ $= 0.1000 \times 25.00 \times 10^{-3}$
$= 2.500 \times 10^{-3}$ mol

(b) $n(\text{excess } H_4Y)$ $= n(Pb(NO_3)_2)$
$= 0.1000 \times 8.26 \times 10^{-3}$
$= 8.26 \times 10^{-4}$ mol

(c) $n(\text{reacted } H_4Y)$ $= n(\text{total } H_4Y) - n(\text{excess } H_4Y)$
$= 2.50 \times 10^{-3} - 8.26 \times 10^{-4}$
$= 1.67 \times 10^{-3}$ mol

(d) $n(PbSO_4)$ $= n(\text{reacted } H_4Y)$
$= 1.67 \times 10^{-3}$ mol

$$[SO_4^{2-}] = \frac{1.67 \times 10^{-3}}{10.0}$$
$= 1.67 \times 10^{-4}$ mol L^{-1}

(e) Fertilisers

Part 4

[Include introduction to Part 4 from last year's STAWA solutions here]

1. The following points could be made:

- Define the Arrhenius model
  i.e. acids produce H^+ in water, and bases produce OH^-.
  Give examples with equations
- Define the Brønsted-Lowry model
  i.e. acids are proton donors and bases are proton acceptors
  Give more examples with equations
- Compare the two models
- Describe the acid-base behaviour of water
  Water can act as an acid or as a base, or both (e.g. self-ionisation)
- Describe how HCl dissolves in water to give an acidic solution
  Give examples of reactions of HCl with bases, and relate them to the two models
- Describe how NaOH dissolves in water to give a basic solution
  Give examples of reactions of NaOH with acids, and relate them to the two models
- Give examples of salts that are neutral, acidic and basic in solution, with equations

2. The following points could be made:

- Describe the common reactions of alkanes, e.g. with halogens
  Give equations, and note that UV light if often needed and the reactions are slow
- Describe (with equations) the reactions of more reactive compounds
  e.g. addition reactions of alkenes/alkynes with hydrogen and halogens
  reactions of alcohols with sodium, $MnO_4^-/Cr_2O_7^{2-}$ or carboxylic acids
  oxidation of alcohols to form ketones, aldehydes or carboxylic acids
  reactions of carboxylic acids and alcohols to form esters
  polymer formation

3. The following points could be made:

- Describe the characteristics of an equilibrium
  e.g. equal forward and reverse reactions, and constant macroscopic properties
- Describe Le Châtelier's Principle, with examples
- Describe the effect of changes on an equilibrium
  e.g. changes in temperature, concentration, pressure, mass or catalysts
- Give examples of equilibrium systems
  e.g. the Contact process, weak acid/base equilibrium, equilibrium involving CO_2.