VICTORIA JUNIOR COLLEGE
2020 JC2 Preliminary Examinations
H2 CHEMISTRY PAPER 1 ANSWERS

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

1 A

Option A:
Cr has 24 electrons. Electronic configuration is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$
Cr has 6 unpaired electrons.

Option B:
Cu has 29 electrons. Electronic configuration is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$
Cu^{2+} has 27 electrons. Electronic configuration is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$
Cu^{2+} has 1 unpaired electron.

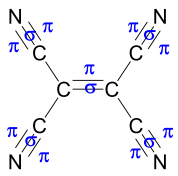
Option C:
Mn has 25 electrons. Electronic configuration is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2$
Mn^{2+} has 23 electrons. Electronic configuration is $1s^2\ 2s^2 2p^6 3s^2 3p^6 3d^5$
Mn^{2+} has 5 unpaired electrons.

Option D:
Te has 52 electrons. Electronic configuration is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^4$
Te^{2-} has 54 electrons. Electronic configuration is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^6$
Te^{2-} has 0 unpaired electron.

2 C

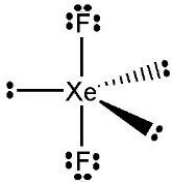
Option	Ion	Electron	Neutrons	Protons	Nucleons
A	W^-	20	18	19	37
B	X^{2+}	15	17	17	34
C	Y^{3+}	14	16	17	33
D	Z^{3-}	18	16	15	31

3 C

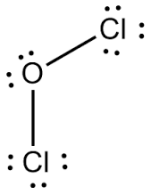


4 C

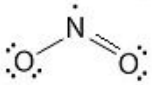
XeF_2 has 2 bond pairs and 3 lone pairs around Xe, geometry is linear.



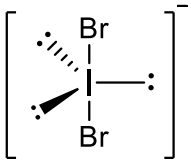
Option A:
Cl_2O has 2 bond pairs and 2 lone pairs around O, geometry is bent.



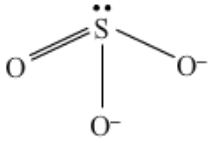
Option B:
NO_2 has 2 bond pairs and 1 lone electron around N, geometry is bent.



Option C:
IBr_2^- has 2 bond pairs and 3 lone pairs around I, geometry is linear.



Option D:
SO_3^{2-} has 3 bond pairs and 1 lone pair around S, geometry is trigonal pyramidal.



5 B

Option 1: Correct
Since volume and temperature are kept constant, using the gas equation $pv = nRT$ pressure is proportional to the number of moles gas.

Option 2: Correct
Manipulation of *pV=nRT* will give the equation $density = \frac{pMr}{RT}$. Density is inversely proportional to the temperature as seen from the equation when the pressure is kept constant.

Option 3: Incorrect
As the units for the temperature in the ideal gas equation is in Kelvins, raising the temperature from 25 °C to 50 °C implies an increase in temperature from 298 K to 323 K. The volume will increase by $\frac{323}{298} = 1.08$ times only.

6 D

Since the options in the formula does not have the gas constant value of 8.31 for *R*, assume, that 1 mol of vapour occupies 22.7 dm^3 at s.t.p. to find a formula for *R*.

$$PV = nRT$$
$$PV = \frac{V}{V_m}RT$$
$$R = \frac{PV_m}{T_{s.t.p.}} - (1)$$

Substitute (1) into the formula $PV = nRT$,

$$PV = n\frac{PV_m}{T_{s.t.p.}}T$$
$$PV = \frac{mass}{Mr}\frac{PV_m}{T_{s.t.p.}}T$$
$$Mr = \frac{mass}{PV}\frac{PV_m}{T_{s.t.p.}}T$$
$$Mr = \frac{0.1 \times 22.7 \times 373}{0.025 \times 273}$$

7 A

From the graph shown, the biggest drop in boiling point occur from element F to G. This implies that element F is silicon while element G is phosphorous.

Option 1: Correct
Since element E is aluminum. The chloride of E will be aluminum chloride. Aluminum chloride reacts with sodium hydroxide to give a white precipitate of aluminum hydroxide as seen in the equation.
$AlCl_3(s) + 3NaOH(aq) \rightarrow Al(OH)_3(s) + 3NaCl(aq)$
The excess sodium hydroxide added will react with the aluminum hydroxide to form a soluble complex ion of $[Na^+Al(OH)_4]^-$.

Option 2: Correct
The oxide of F is silicon dioxide. SiO_2 does not dissolve in water as large amount of energy are required to break the strong Si**–**O covalent bonds in the giant molecular structure. Therefore, the pH of the resultant mixture is 7.

Option 3: Correct
The oxide of K is potassium oxide. K_2O is a basic oxide which readily dissolves in water to give a strongly alkaline solution of potassium hydroxide.
$K_2O(s) + H_2O(l) \rightarrow 2KOH(aq)$

8 D

From the graph shown, the biggest drop in the 2nd ionisation energy implies electrons are removed from a different shell. Hence the element after option B is sodium and the element before option C is magnesium. Since the elements are arranged consecutively, Option A is oxygen, Option B is neon, Option C is aluminum and Option D is silicon.

Option D is element P as silicon has poor electrical conductivity and silicon chloride is a simple molecule with a simple molecular structure.

9 B

Option A: Incorrect
Although the statement is true, as barium loses electrons more easily than magnesium to form an ion. It does not explain about the solubility of the two ionic compounds.
Option B: Correct
The statement is true.
$\Delta H_{sol} = -\Delta H_{LE} + \sum \Delta H_{hyd}$
$\Delta H_{hyd} \propto \left|\frac{q^+}{r^+}\right|$
Since magnesium ion has a higher charge density than barium ions, the enthalpy change of hydration of magnesium sulfate will be much more exothermic. This will result in the ΔH_{sol} of magnesium sulfate to be more exothermic than barium sulfate.
Option C: Incorrect
A numerically larger lattice energy implies that more energy is needed to break the lattice hence solubility of magnesium sulfate should be lower.
Option D: Incorrect
The statement is not true.
$\Delta H_{hyd} \propto \left|\frac{q^+}{r^+}\right|$
The magnitude of the ΔH_{hyd} is proportional to the charge density of the ions. Since barium ion has a larger ionic radius than magnesium ion, it has a lower charge density and therefore less exothermic enthalpy change of hydration than magnesium ion.

10 D

Option A: Incorrect
Astatine has more electron shells than bromine. The orbital overlap between hydrogen and astatine atoms will be less effective than the orbital overlap between hydrogen and bromine atoms. Therefore, the bond strength of H**–**At will be weaker than H**–**Br implying a lower decomposition temperature.
Option B: Incorrect
Going down group 17, the physical colour of the element changes from a pale-yellow chlorine to a black solid iodine. Since the position of astatine is below iodine in the periodic table, it should a dark coloured solid.
Option C: Incorrect
Going down group 17, the solubility product of silver halides decreases. Since the position of astatine is below iodine in the periodic table, when $NH_3(aq)$ is added, the ionic product of silver astatide will still exceed the solubility product, making it insoluble.
Option D: Correct
Going down group 17, the $E^\ominus$ value becomes less positive, this implies that iodine should have a more positive $E^\ominus$ value than astatine. Therefore, iodine will undergo reduction instead, making it a stronger oxidising agent than astatine.

11 B

No. of atoms = Amount of atoms x 6.02 x 10^{23}
$\Rightarrow$ no. of atoms α amount of atoms
Option that gives the largest amount of atoms is the answer.

Option A:
Each O_2 molecule has 2 O atoms.

Amount of atoms = $\frac{24}{24}$ x 2 = 2 mol

Option B:
Each N_2 molecule has 2 N atoms.

Amount of atoms = $\frac{65}{14.0+14.0}$ x 2 = 4.64 mol

Option C:
Each CH_3CH_2OH molecule has 9 atoms.

Amount of atoms = $\frac{18.75 \text{ x } 0.8}{2(12.0)+6(1.0)+16.0}$ x 9

= 2.93 mol

Option D:

Amount of atoms = $\frac{254}{63.5}$ = 4 mol

12 A

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

0.99y 0.99y

$CH_4(g) + \frac{3}{2}O_2(g) \rightarrow CO(g) + 2H_2O(g)$

0.01y 0.01y

Volume of O_2 used = 2(0.99y) + 3/2(0.01y)

= 2y(1–0.01) + 1.5(0.01y)

= 2y –2y(0.01) + 1.5y(0.01)

= (2y – $\frac{0.01y}{2}$) dm^3

13 A

End point is reached when volume of H_2O_2 = 70 cm^3

Thus volume of $KMnO_4$ reacted = 100 – 70

= 30 cm^3

Amount of H_2O_2 = 5/2 x 30 x 10^{-3} x 0.50

= 3.75 x 10^{-2} mol

$[H_2O_2] = \frac{3.75 \text{ x } 10^{-2}}{70 \text{ x } 10^{-3}}$

= 0.536 mol dm^{-3}

Heat evolved = mcΔT

= 100 x 4.2 x 13.5

= 5670 J

$\Delta H = -\frac{5670}{3.75 \text{ x } 10^{-2}} \text{ x } 10^{-3}$

= – 151 kJ mol^{-1}

14 B

Let the change in $P_{azomethane}$ be y Pa.

$CH_3N{=}NCH_3(g) \rightarrow CH_3CH_3(g) + N_2(g)$

Initial P	16	0	0
Change	–y	+y	+y
Eqm P	16–y	y	y

When total pressure = 30 Pa,

16 – y + y + y = 30

y = 14 , i.e. $P_{azomethane}$ = 16 – 14 = 2 Pa.

16 $\xrightarrow[t_{1/2}]{}$ 8 $\xrightarrow[t_{1/2}]{}$ 4 $\xrightarrow[t_{1/2}]{}$ 2

When $P_{azomethane}$ decreases from 16 Pa to 2 Pa,

time taken = $3t_{1/2}$

= 3 x 20

= 60 min

15 A

Option 1: Correct
K_c is dependent on temperature only.
Since temperature remains constant, K_c values at 7.5 min and 15 min are the same.

Option 2: Correct
$CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$
At 7.5 min, concentrations of all the gases in the equilibrium mixture increase. This is due to the decrease in volume which results in an increase in pressure at constant temperature. By *Le Chatelier's Principle*, the equilibrium position shifts right to decrease the pressure by forming less gaseous molecules. Hence, [CO] and [Cl_2] decrease, while [$COCl_2$] increases after 7.5 min.

Option 3:
$CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$
At 10 min, [Cl_2] increases as more Cl_2 is added to the equilibrium mixture. By *Le Chatelier's Principle*, the equilibrium position shifts right to remove some Cl_2. Thus, [CO] and [Cl_2] decrease, while [$COCl_2$] increases after 10 min.

16 D

Option A: Incorrect
pH = 2 $\Rightarrow$ $[H^+] = 10^{-2}$ mol dm^{-3}
$[HA] = 0.1$ mol dm^{-3}
Since $[H^+] < [HA]$, HA has dissociated partially to form H^+ ions $\Rightarrow$ HA is a weak acid.

pH = 3 $\Rightarrow$ $[H^+] = 10^{-3}$ mol dm^{-3}
$[HB] = 0.001$ mol dm^{-3}
Since $[H^+] = [HB]$, HB has dissociated completely to form H^+ ions $\Rightarrow$ HB is a strong acid.
Thus HA is a weaker acid than HB.

Option B: Incorrect
Since HA is a weaker acid than HB, the conjugate base of HA is stronger than that of HB
$\Rightarrow$ pK_b of A^- is lower than pK_b of B^-

Option C: Incorrect
At equivalence point, only the salt is present. Neutralisation of HA (weak acid) with NaOH (strong base) will result in the formation of a basic salt, NaA due to hydrolysis. An excess of OH^- ions are produced, giving a pH that is greater than 7.

$A^- + H_2O \rightleftharpoons HA + OH^-$

Neutralisation of HB (strong acid) with NaOH (strong base) will result in the formation of a neutral salt, NaB. There is no hydrolysis of B^-. The ions are only solvated by water. pH of the aqueous solution is 7.

Option D: Correct
Working range of methyl orange indicator is in the acidic region (pH 3.1 – 4.4). It does not lie within the

range of rapid pH change (pH = 7 to 10) for the weak acid-strong base titration.

17 B

A buffer should contain a mixture of a weak acid and its salt or a mixture of a weak base and its salt.

Option 1: Correct

$CO_2 + H_2O \rightleftharpoons H_2CO_3$

Mixture contains a dissolved CO_2 (H_2CO_3), a weak acid and its conjugate base, HCO_3^- from the salt, $NaHCO_3$, constituting an acidic buffer.

Option 2: Incorrect

$NaHCO_3 + HCl \rightarrow H_2CO_3 + NaCl$

0.300 mol 0.400 mol

(excess)

Resultant mixture contains the weak acid H_2CO_3. However, there is no $NaHCO_3$ left as it is completely reacted. Hence, there is no buffer.

Option 3: Correct

$NaHCO_3 + NaOH \rightarrow Na_2CO_3 + H_2O$

0.300 mol 0.200 mol

(excess)

Resultant mixture contains the weak base, Na_2CO_3 and its salt, $NaHCO_3$. Thus a basic buffer is formed.

Option 4: Correct

Mixture contains the weak base, Na_2CO_3 and its salt, $NaHCO_3$. This mixture constitutes a basic buffer.

18 C

Let y mol dm^{-3} be the max allowed $[Cl^-]$ in the total volume of 2 cm^3 solution.

$y \times [Ag^+] = 1.8 \times 10^{-10}$

$$y \times \left(\frac{1 \times 10^{-3} \times 1}{2 \times 10^{-3}}\right) = 1.8 \times 10^{-10}$$

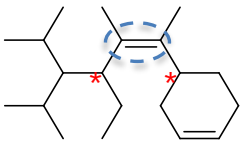
$y = 3.6 \times 10^{-10}$ mol dm^{-3}

Therefore max. allowed conc. of chloride ions in the water that leave the column

$= 2 \times 3.6 \times 10^{-10}$

$= 7.2 \times 10^{-10}$ mol dm^{-3}

19 B



Compound has 2 chiral centres and 1 C=C that can exhibit cis-trans isomerism.

No. of stereoisomers = 2^{2+1}

= 8

20 A

Option 1: Correct

$CH_3(CH_2)_4CH_2Br + NaCN(alc) \rightarrow CH_3(CH_2)_4CH_2CN + NaBr$

Organic product has no chiral centre. Hence, mixture will be optically inactive.

Option 2: Correct

$CH_3CH_2C(Br)(CH_3)CH_2CH_2CH_3 + NaOH(aq) \rightarrow CH_3CH_2C(OH)(CH_3)CH_2CH_2CH_3 + NaBr(aq)$

$CH_3CH_2C(Br)(CH_3)CH_2CH_2CH_3$ is a tertiary halogenoalkane and will undergo unimolecular nucleophilic substitution (S_N1) with NaOH(aq) to form a carbocation, $CH_3CH_2C^+(CH_3)CH_2CH_2CH_3$, in the first step, which is trigonal planar with respect to the positively charged carbon. In the second step, OH^- can attack the positively charged C from the top or bottom of the plane with equal probability, giving a racemic mixture, i.e. 50% of each enantiomer of $CH_3CH_2C^*(OH)(CH_3)CH_2CH_2CH_3$. Thus mixture is optically inactive.

Option 3: Correct

$CH_3CH_2CH=CH_2 + HBr \rightarrow CH_3CH_2CH(Br)CH_3$

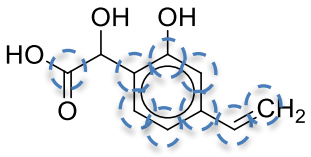
$CH_3CH_2CH=CH_2$ undergoes electrophilic addition with HBr to form a carbocation, $CH_3CH_2C^+HCH_3$, in the first step, which is trigonal planar with respect to the positively charged carbon. In the second step, Br^- can attack the positively charged C from the top or bottom of the plane with equal probability, giving a racemic mixture, i.e. 50% of each enantiomer of $CH_3CH_2C^*H(Br)CH_3$. Thus mixture is optically inactive.

Option 4: Correct

$CH_3COCH_2CH_3 + HCN \xrightarrow{\text{trace of NaCN}} CH_3C(OH)(CN)CH_2CH_3$

In the first step, CN^- can attack the trigonal planar carbonyl C from the top or bottom of the plane with equal probability, giving two intermediates $CH_3C(O^-)(CN)CH_2CH_3$ which are enantiomeric with each other. In the second step, both intermediates are subsequately protonated by HCN to form a racemic mixture, i.e. 50% of each enantiomer of $CH_3C^*(OH)(CN)CH_2CH_3$. Thus mixture is optically inactive.

21 D



Option A: Incorrect

There are 9 sp^2 hybridised carbon atoms.

Option B: Incorrect

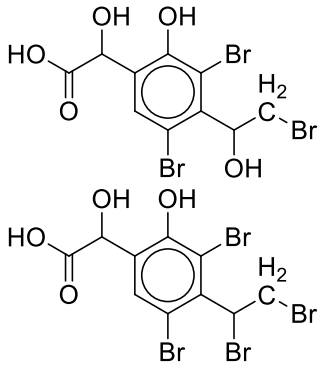
Z undergoes an acid-base reaction with aqueous ammonia to give a salt.

Option C: Incorrect

1 mol of produced 1.5 mol of hydrogen gas when reacted with excess sodium..

Option D: Correct

The two products formed are:

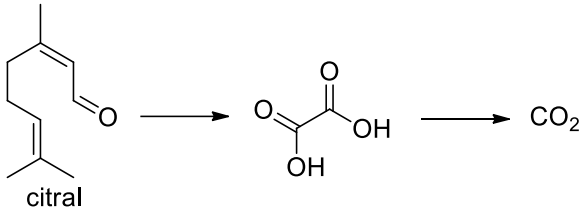


Therefore it is possible to have up to 4 bromine atoms incorporated.

22 A

Option A: Correct

Citral upon undergoing oxidative cleavage produces ethandioic acid which undergoes further oxidation to give carbon dioxide gas.



Citronellal does not produce carbon dioxide gas when reaction with hot acidified potassium manganate(VII)

Option B: Incorrect

Both compounds will undergoes partial oxidation to produces diol, so there will not be any different observations.

Option C: Incorrect

Both compounds contain aldehyde functional group hence will produce a brick red ppt. when reaction with Fehling's solution.

Option D: Incorrect

Both compounds contain alkene functional group will decolourise liquid bromine

23 A

Option 1: Correct

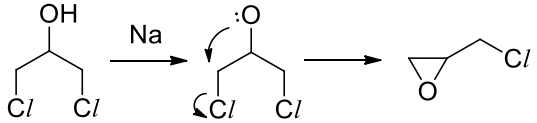
Stage 1 shows the formation of a chloroalkane from an alkane hence it is a free-radical substitution which requires the use of UV.

Option 2: Correct

Stage 2 shows the alkene (electron-rich) undergoing a reaction to form a saturated compound, hence it is an electrophilic addition.

Option 3: Correct

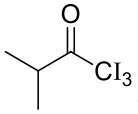
Reaction that occurs is as below.



The lone pair on the oxygen will attack the election deficient carbon atom to form a carbon-oxygen bond and the original carbon-chlorine breaks.

24 C

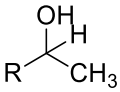
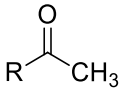
Option A: Correct

Compound shown will undergo further substitution with iodine to form  which then undergo oxidative cleavage to produce yellow ppt of tri-iodomethane.

Option B: Correct

The compound will first undergoes hydrolysis to produce ethanoate and ethanol. Ethanol will then undergoes the iodoform reaction to produce the yellow ppt of tri-iodomethane.

Option C: Correct

The compound does not have either  or  hence will not produce the yellow ppt of tri-iodomethane with hot alkaline aqueous iodine.

Option D: Correct

Ethanol will undergoes the iodoform reaction to produce the yellow ppt of tri-iodomethane.

25 D

Option A and B: Incorrect

The carbonyl C atom in C_6H_5COCl is highly electron deficient due to the electron-withdrawing inductive effect of the highly electronegative O atom, together with the C*l* atom, making it more susceptible to nucleophilic attack than RCH_2Cl and C_6H_5Cl. The time taken for the appearance of the silver halide ppt. will be the shortest.

Option C: Incorrect

The C–Br in $CH_3CH{=}CHBr$ has partial double bond character hence is less reactive towards nucleophilic substitution than $C_6H_5CH_2Br$. The time taken for the appearance of the silver halide ppt. with $C_6H_5CH_2Br$ will be shorter.

Option D: Correct

The C–C*l* in C_6H_5Cl has partial double bond character hence is less reactive towards nucleophilic substitution than $C_6H_5CH_2Cl$. The time taken for the appearance of the silver halide ppt. with $C_6H_5CH_2Cl$ will be shorter.

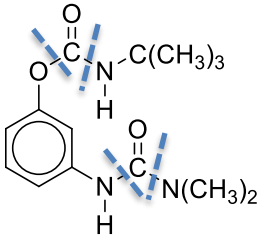
Bond energy of C–C*l* = 340

Bond energy of C–Br = 280

C–Br bond is weaker hence $C_6H_5CH_2Br$ is more susceptible to nucleophilic attack than $C_6H_5CH_2Cl$. The time taken for the appearance of the silver halide ppt. with $C_6H_5CH_2Br$ will be shorter.

26 D

The compound will undergo basic hydrolysis.

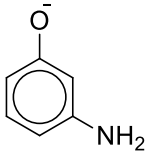


Option A: Incorrect

The two amines produced are $(CH_3)_2NH$ and $(CH_3)_3CNH_2$

Option B: Incorrect

Since hydrolysis is carried in a basic medium, the correct product is



Option C: Incorrect

The compound shown will undergo further hydrolysis

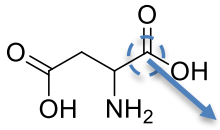
Option D: Correct

The salt, Na_2CO_3 will be formed

27 B

Since S reacts with $Ag(NH_3)_2^+$ (Tollens' reagent) to produce a grey ppt (silver mirror) it must be an aldehyde. Hence R must be a primary alcohol since S is formed from the oxidation of R. The starting compound is therefore a primary bromoalkane, $CH_3CH_2CH_2Br$. The bromoalkane undergoes a nucleophilic substitution to produce the primary alcohol R, $CH_3CH_2CH_2OH$. R is oxidised to form the aldehyde S, CH_3CH_2CHO. S then produce a silver mirror and the carboxylate ion, $CH_3CH_2CO_2^-$.

28 C



α carbon

Order of acidity:

α carboxylic acid (pK_a = 2.10) > alkyl carboxylic acid (pK_a = 3.86) > protonated amine (pK_a = 9.82)

At low pH medium, aspartic acid exists as fully protonated form, $H_3N^+-CH(CH_2CO_2H)-CO_2H$. When the pH of the medium is raised to 7, as pH 7 > pK_a of α carboxylic acid and alkyl carboxylic acid, these two groups will get deprotonated. Hence, the major species present in solutions of aspartic acid at pH 7 is $H_3N^+-CH(CH_2CO_2^-)-CO_2^-$.

29 D

$E^o(Sn^{2+}|Sn) = -0.14$ V

$E_{cell} = E_{red} - E_{oxid} = E^o(H^+|H_2) - E^o(Sn^{2+}|Sn)$

When $[H^+(aq)]$ was lower than 1.00 mol dm^{-3} $E^o(H^+|H_2)$ will be more negative resulting in a less positive E_{cell}.

When$[Sn^{2+}(aq)]$ was greater than 1.00 mol dm^{-3} $E^o(Sn^{2+}|Sn)$ will be more positive resulting in a less positive E_{cell}.

30 C

The same quantity of charges hence amount of electrons passed throughthe 4 electrodes

Let the amount of electrons be y.

At electrode E,

Aluminium is oxidised. Change in mass = mass of Al lost = y/3 x A_r (Al) = 27.0y/3 g

At electrode F,

Water is reduced to form hydrogen gas which will leave the cell. Hence there is no change in mass.

At electrode G,

Silver is oxidised. Change in mass = mass of Ag lost = y x A_r (Ag) = 107.9y g

At electrode H,

Copper(II) ions are reduced to form copper metal. Change in mass = mass of Cu formed = y/2 x A_r (Cu) = 63.5y/2 g

.