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Free Exam
for 2013-16 VCE study design

Engage Education Foundation

Units 3 and 4 Chemistry

Practice Exam Solutions

Stop!

Don't look at these solutions until you have attempted the exam.

Any questions?

Check the Engage website for updated solutions, then email practiceexams@ee.org.au.

Section A – Multiple-choice questions

Question 1

The correct answer is D.

Stem from longest chain containing the double bond: hept- (7)
Double bond origin at first carbon: hept-1-ene
3-carbon substituent at C3, 1-carbon substituent at C5: 3-propyl and 5-methyl
List substituents in alphabetical order: **5-methyl-3-propylhept-1-ene**

Question 2

The correct answer is C.

Oxidation number of S in $H_2S_2O_3$ is +2 (H is +1 with non-metals; O is -2; sum of all oxidation states must add to 0 in neutral compound).
Because H(+1), O(-2), Cl (-1) and F(-1) in compounds above, oxidation state of S in options A, B, C and D is +4, +5/2, +2 and +5 respectively.
Therefore, option (c) is the only one with matching oxidation number.

Question 3

The correct answer is B.

Starting pH of 11 indicates that initial reactant is a weak base.
pH at equivalence point is approximately pH 5 – because pH at equivalence point is below 7, it must be reaction between weak base and strong acid.

Question 4

The correct answer is A.

From graph, it is possible that any indicator that changes form/colour between pH 3 and 7 may be appropriate, due to sharp end point at approximately pH 5.
Using VCE Chemistry Data Book, the indicators in options (b), (c), (d) all fall within this range, whereas Thymol Blue has a range from 1.2-2.8; hence not appropriate.

Question 5

The correct answer is C.

Esterification requires reaction between a primary alkanol and a carboxylic acid, therefore answer must be C: propan-1-ol (it is the only primary alkanol present)
Confirmed by naming the original carboxylic acid:

- Longest chain: – hexanoic acid
- Methyl group attached to the 4th carbon (the carbon in the carboxyl group must be numbered 1) – 4-methylhexanoic acid

Question 6

The correct answer is B.

To form biodiesel, triglycerides from animal fats or plant oils are hydrolysed into fatty acids and glycerol, and the fatty acids then react with small alkanols (usually methanol or ethanol) to form esters.
This is catalysed by sodium hydroxide, or another strong base.
Therefore glycerol is a product, not a reactant/catalyst.

Question 7

The correct answer is A.

Immediately rule out (b) (is a base so would decrease hydronium concentration) and (c) (has a smaller K_a than HF; because they are equimolar, this means HF have a greater hydronium concentration due to greater extent of ionisation).
Complete ionisation of HCl as strong acid, therefore $[H_3O^+] = [HCl]$, and so concentration is 0.1 M
For HF: $K_a = \frac{[F^-][H_3O^+]}{[HF]} \rightarrow 7.6 \times 10^{-4} = \frac{[H_3O^+]^2}{1.0} \rightarrow [H_3O^+] = 2.8 \times 10^{-2}\ M$
Therefore, HCl has the highest hydronium concentration.

Question 8

The correct answer is B.

(d) is correct procedure, will not result in change.
(a) and (c) are both erroneous procedures that would require a greater volume of HCl to neutralise the NaOH, which would lead to its calculated concentration being less than the actual.
(b) may dilute the NaOH in the pipette, which means less HCl would be required to neutralise it, and so the concentration of the HCl would be calculated to be higher than the actual.

Question 9

The correct answer is C.

Mass spectrometry can be used to detect the relative abundances of ions of a particular mass in a sample, so would be most suitable for detecting the amounts of the isotopes present.

Question 10

The correct answer is D.

Converting to appropriate units gives P = 101.3 kPa, V = 1.982 L, and T = 297 K; recall that R = 8.314 J/K/mol.

$pV = nRT \rightarrow 101.3 \times 1.982 = n \times 8.314 \times 297 \rightarrow n = 0.0813\ mol$

Thus, molar mass of gas is equal to $M = \frac{m}{n} = \frac{2.44}{0.0813} = 30.0\ g/mol$

Therefore, answer is (d), as NO is the only option with molar mass of 30.0 g/mol.

Question 11

The correct answer is B.

Peptide (amide) linkages are covalent linkage group that are responsible for maintaining the primary structure of the protein, not tertiary.
The other three options are all responsible for determining the tertiary structure.

Question 12

The correct answer is B.

The second reaction is anaerobic respiration in yeast; that is, fermentation of glucose to ethanol and carbon dioxide in the absence of oxygen.
(a), (c) and (d) are aerobic respiration, anaerobic respiration in animals and photosynthesis respectively.

Question 13

The correct answer is C.

The question is essentially asking which fatty acid has the highest proportion, or amount, of C=C double bonds in the alkyl chain (both interpretations will lead to the correct answer).
Using the VCE Chemistry Data Book, can use the general formula for saturated fatty acids, $C_nH_{2n+1}COOH$, in addition to the knowledge that each double bond results in two less hydrogens, to calculate that arachidonic acid has four C=C double bonds, whereas the other options either have none or one.

Question 14

The correct answer is B.

The structure of dimethylpropan-1-ol:
All H's in the three methyl groups are equivalent; the H in the hydroxyl group has a unique environment and the other H's attached to the same C also have a unique environment. Therefore, there are three distinct peaks in the low-res ^{1}H NMR spectrum.
The three C's in the methyl groups attached to the central carbon are equivalent; the central carbon and the terminal carbon attached to the hydroxyl group both have unique bonding environments. Therefore, there will be three peaks in the ^{13}C NMR spectrum.

Question 15

The correct answer is C.

Carboxylic acids are formed by the oxidation of primary alkanols in the presence of a strong oxidant such as acidified potassium permanganate or acidified potassium dichromate.

Question 16

The correct answer is D.

(a) and (b) are possibly both acceptable, contributing explanations.
(c) is unrelated to rate, and is also an inaccurate statement.
The **best** explanation is (d), as the effect of this is that there is an increased proportion of 'successful collisions', which is contributes more significantly to increased rate of reaction that simply a higher frequency of collisions in total.

Question 17

The correct answer is A.

Must be written as products over reactants.
Solid reagents are not to be included (as they do not have a 'concentration').

Question 18

The correct answer is B.

Reaction is exothermic, therefore increasing temperature will <u>decrease</u> yield.

Question 19

The correct answer is C.

Catalysts act by decreasing the activation energy barrier for an equilibrium system.
Therefore, due to the lower energy threshold, the rates of both the forward and back reactions increase.

Question 20

The correct answer is C.

ΔH is the difference in energy between the reactants and the products
From graph, can be seen that difference is 276 kJ/mol
Positive sign confirmed by an overall increase in energy (endothermic)

Question 21

The correct answer is B.

E_A = 473 – 276 = 196 kJ/mol

Question 22

The correct answer is C.

$[H_3O^+] = 10^{-pH} = 10^{-7.8} = 1.585 \times 10^{-8}\ M$

$[H_3O^+][OH^-] = 10^{-14} \rightarrow [OH^-] = \frac{10^{-14}}{[H_3O^+]} = 6.3 \times 10^{-7} M$

Question 23

The correct answer is A.

$$CF = \frac{VIt}{\Delta T} = \frac{7.45 \times 3.20 \times 23.4}{0.45} = 1239.68 \cong 1240$$

Question 24

The correct answer is D.

$Energy = CF \times \Delta T = 1239.68 \times 0.780 = 966.95$

$\Delta H = \frac{energy}{n} = \frac{966.95}{0.0035} = 276271.5\ J = 276\ kJ$

Combustion reaction, therefore ΔH must be negative (i.e. energy released)

Question 25

The correct answer is D.

Because the Cu^{2+}/Cu half equation is significantly higher on the electrochemical series, it will proceed spontaneously as a reduction reaction (forwards), whilst the Al^{3+}/Al half equation (backwards).
Electrons lost and gained must be balanced, so copper half equation must be multiplied by 3 and aluminium half equation must be multiplied by 2 in order to achieve this.

Question 26

The correct answer is D.

The question states that the galvanic cell was set up at $35^{O}C$.
The electrochemical series is accurate for reactions at standard conditions, which includes a temperature of $25^{O}C$ – where the temperature deviates, the values half-cell potentials listed in the series are no longer applicable/accurate.
Thus, the potential difference for the cell cannot be determined here without further information.

Question 27

The correct answer is B.

The internal circuit of a galvanic cell refers to the flow of ions through the salt bridge in order to conserve charge in the half-cells

Question 28

The correct answer is A.

Water is a stronger oxidant than Ca^{2+}, and so would reduce preferentially to it at the cathode of an electrolytic cell, thus calcium would not be produced.
Therefore, a molten electrolyte (hence no water present) is required.
The other metals listed are all stronger oxidants than water.

Question 29

The correct answer is C.

Methane can be generated from the decay or organic material in the presence of oxygen; hence it is renewable
The other three options are either non-renewable/finite, or are unable to be replenished at a rate sufficient to keep up with the rate of consumption.

Question 30

The correct answer is B.

t in seconds = (83 x 60) + 20 = 5000 s
Q = I x t = 135.1 x 5000 = 675 550 C
Q = n(e-) x F → n(e-) = Q ÷ F = 675550 ÷ 96500 = 7 mol
Charge on metal is 2+, therefore two electrons consumed for every one mole of metal formed; therefore, n(metal) = 7÷2 = 3.5 mol
M(metal) = m ÷ n = 85.05 ÷ 3.5 = 24.3 g/mol
Thus metal is Magnesium (Mg.)

Section B – Short-answer questions

Marks allocated are indicated by a number in square brackets, for example, [1] indicates that the line is worth one mark.

Question 1a

Weak base [1 mark]
Initial pH 11, therefore weak base [1 mark]
pH at equivalence point is below 7, therefore strong acid/weak base rxn [1 mark]

Question 1b

Equivalence point: the point in the titration when the reactants have been mixed exactly according to the mole ratios in the equation (or any equivalent explanation) [1 mark]
End point: The point in the titration when the indicator changes colour [1 mark]

Question 1c

Methyl red [1 mark] – from Data Book, only indicator with a range that includes pH 5.5

Question 1d

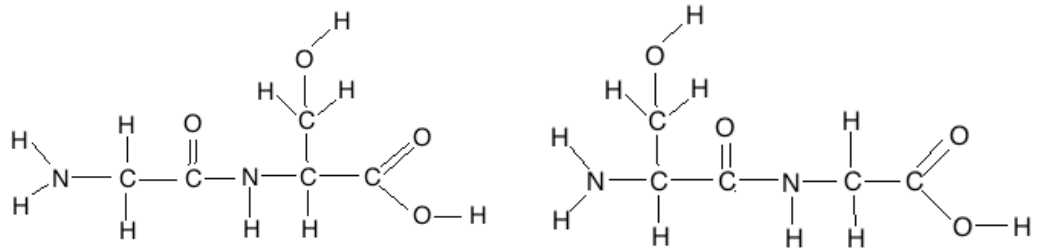
$n(HCl) = c \times V = 1.00M \times 0.0200\,L = 0.0200\,mol$ [1 mark]
n(HCl) = n(XOH) because they react 1:1 [1 mark]
$c(XOH) = \frac{n}{V} = \frac{0.0200}{0.0450} = 0.444\,M$, to 3 sig figs [1 mark]

Question 1e

Would dilute HCl slightly [1 mark]
Therefore would require greater volume of HCl to neutralise base [1 mark]
Thus, given fixed volume, calculated concentration of base would be higher than actual [1 mark]

Question 2a

1 mark for each of the structures below, if complete and correct



Question 2b

1 mark for circling –CONH– group and labelling 'peptide' (amide also accepted)
1 mark for circling H_2N– group and labelling 'amine' or 'amino'
1 mark for circling –COOH group and labelling 'carboxyl'

Question 2c

Condensation polymerisation or condensation; water (H_2O) [1 mark]
Must correctly identify both to gain the mark

Question 2d

Amino group acts as a base, accepts proton from water molecule (nitrogen attached to three hydrogens, gains positive charge) [1 mark]
Carboxyl group acts as acid, donates proton to water molecule (forms $–COO^-$ group) [1 mark]

Question 3a

Le Chatelier's Principle is that when an equilibrium system is subjected to a change, the system will adjust to partially oppose the change's effect [1 mark – wording is flexible, but must reference *equilibrium*, *change*, and *partially oppose/offset/etc*.]

Question 3b i

Increase in energy of system; system will respond by favouring reaction that consumes energy [1 mark]
Because system is exothermic, favours the reverse reaction (or position of equilibrium shifts to left), therefore ethanol yield decreases [1 mark]

Question 3b ii

Increase in volume is decrease in pressure; system will respond by favouring reaction that will cause increase in pressure [1 mark]
Greater relative number of moles of gas on products side as opposed to reactants, therefore system will favour the forward reaction (or position of equilibrium shifts to right), and therefore ethanol yield increases [1 mark]

Question 3b iii

Argon is an inert gas (addition of an inert/unreactive gas does not alter partial pressures of gases in the system). No change = no effect on yield [1 mark]

Question 3c i

Advantages may include [1 mark each for any two]:
Derived from carbohydrates found in plant material, so can be considered 'renewable'.
Generally uses waste material left over after food production, therefore helping to reduce wastage.
Uses readily available raw materials (plant material), so less likely to be influenced by political/economic problems associated with importing raw materials.
Much closer to being 'carbon neutral' than conventional fossil fuels, as the carbon dioxide released is equal to the carbon dioxide consumed by the plants from which it is derived during photosynthesis (although some carbon dioxide emissions from fossil fuel are still required to power the process to produce the ethanol).

Question 3c ii

Disadvantages may include (1 mark for any one):
Possibility of 'energy crops' reducing the amount of land available for agriculture/food crops, possibility stimulating a food shortage or strain.
Environmental issue of waste disposal of fermentation liquors
Less efficient than petroleum; has a lower heat of combustion per unit mass
Many current engines/machinery would require modification to be able to use ethanol as a fuel source

Question 4a i

Only one unique hydrogen bonding environment [1 mark]
Either CH_3COOR or CH_3COR (see Data Book) [1 mark]

Question 4a ii

Two unique carbon bonding environments [1 mark]
An R–CH_3 and an RCOOH or similar [1 mark]

Question 4a iii

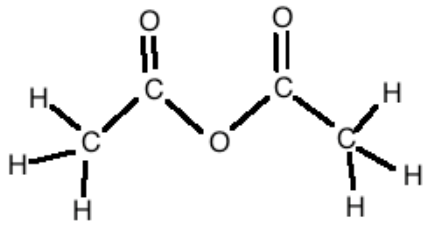
Molecular ion peak at m/z=102, therefore relative molecular mass of 102 [1 mark]
Base peak (or a strong peak) at m/z=43, therefore there is a common fragment formed with a relative molecular mass of 43 [1 mark]

Question 4a iv

Strong peaks at around 1100, 1300, 1750 cm^{-1} indicative of C–C, C–O, and C=O groups [2 marks for all three, 1 mark for identifying two]
Absence of peak at 2500-3300 and 3200-3550 suggests no O-H groups [if identified only two of the above groups, can gain second mark with this observation]

Question 4b

[2 marks awarded for correct structure (acetic anhydride)]



Question 5a i

Addition (or hydrolysis) [1 mark]

Question 5a ii.

Oxidation [1 mark]

Question 5a iii.

Esterification (or condensation) [1 mark]

Question 5b i

Water (reactant) and phosphoric acid (catalyst) [1 mark each]

Question 5b ii

Acidified potassium dichromate or acidified potassium permanganate catalyst [1 mark for either one of these]

Question 5b iii

Concentrated sulphuric acid catalyst [1 mark]

Question 5c

Propyl propanoate [1mark]

Question 5d i

Infrared radiation provides molecules with an amount of energy that causes them to vibrate due to stretching and bending of covalent bonds [1 mark]

Infrared radiation spectroscopy provides information about the functional groups and types of bonds present in a molecule [1 mark]

Question 5d ii.

The presence/absence of a peak at either one of 2500-3300 cm^{-1} or 3200-3550 cm^{-1}, indicating O-H (acid) and O-H (alcohols) respectively. [1 mark]
If peak present, reactant (either propanoic acid or propan-1-ol, depending on choice) still present, and so reaction has not proceeded to completion; conversely, if peak not present, than all reactant has been converted. [1 mark]

Question 6a

$E = VIt$ and $Q = It$, therefore $E = QV$ [1 mark]
Therefore, $Q = \frac{E}{V} = \frac{518\,400\ J}{6.40\ V} = 81\,000\ C$ [1 mark]
$Q = n(e-) \times F \rightarrow n(e-) = \frac{Q}{F} = \frac{81\,000}{96\,500} = 0.8394\ mol$ [1 mark]
n(Na) = n(e-) because sodium ion has a charge of 1+, so one electron gained for every Na atom produced [1 mark]
$m(Na) = M \times n = 23.0 \times 0.8394 = 19.3\ g$ [1 mark]
[1 mark for 3 sig figs and units correct throughout]

Question 6b

If water were present, it would be reduced preferentially to sodium at the cathode [1 mark] and so no metal would form [1 mark].

Question 6c

[1 mark for each point (a similar process with a different, but still correct, precipitate will be accepted)]
Weigh sample, blend/filter so that all chloride ions from sample are in solution
Add excess of $AgNO_3$ to precipitate chloride ions as insoluble AgCl
Filter and collect the precipitate
Wash with small volume of water and dry to constant mass at ~110ºC
Weigh AgCl sample
Use mass to perform stoichiometric calculations to determine the molar amount of chloride present (hence NaCl), can then calculate concentration

Question 7a

$C2H_6(g) + Cl_2(g) \xrightarrow{UV\ light\ \boldsymbol{OR}\ heat} C_2H_5Cl\ (g) + HCl(g)$
[1 mark for reactants/products all correct, 1 mark for both states and condition]

Question 7b

$K = \frac{[C_2H_5Cl][HCl]}{[C_2H_6][Cl_2]}$ [1 mark]

Question 7c

[2 marks for determining n of all species at equilibrium]
n(C_2H_6) = 0.340 – 0.1114 = 0.2286 mol
n(Cl_2) = 0.780 – 0.1114 = 0.6686 mol
n(C_2H_5Cl) = n(HCl) = 0.1114 mol
[1 mark for converting all to concentrations by dividing moles by volume (4.00 L)]
[C_2H_6] = 0.05715 M; [Cl_2] = 0.16715 M; [C_2H_5Cl] = [HCl] = 0.02785 M
[1 mark for correct value of K]

$$K = \frac{[C_2H_5Cl][HCl]}{[C_2H_6][Cl_2]} = \frac{0.02785 \times 0.02785}{0.05715 \times 0.16715} = 0.0812$$

Question 7d

Catalyst provides an alternative reaction pathway that reduces activation energy [1 mark]
This results in a higher proportion of 'successful' collisions between reactant particles, in which particles collide with energy sufficient to overcome the activation energy barrier [1 mark]
Consequently, the rate of both the forward and back reactions increase, so equilibrium is reached more quickly. [1 mark]
Presence of a catalyst has no effect on value of equilibrium constant, therefore it does not result in any change to ultimate yield of the reaction. [1 mark]

Question 8

Molar volume at STP = 22.4 L/mol
$n(H_2) = \frac{V}{V_m} = \frac{3.410\ L}{22.4\ L/mol} = 0.1522\ mol$ [2 marks]
$n(H_2) = n(Cu)$ because they react 1:1, $\therefore n(Cu) = 0.1522\ mol$ [1 mark]
$m(Cu) = M \times n = 63.5 \times 0.1522 = 9.6647\ g$ [1 mark]
$\%\ w/w\ (Cu) = \frac{9.6647}{10.5} \times 100 = 92.0\ \%$ [1 mark]

Question 9a

Fuel cells convert energy directly from chemical → electrical [1 mark]
Energy from combustion of fossil fuels is transferred from chemical → thermal → mechanical → electrical [1 mark]
Energy is lost at each stage of conversion, so the less conversions, the more efficient the energy transfer [1 mark]

Question 9b i

$H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2e^-$

Question 9b ii

$O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$

Question 9b iii

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

Question 9c

A primary cell has a fixed/limited initial amount of reactants [1 mark]
A fuel cell requires a continuous supply of reactants [1 mark]

Question 9d

[1 mark each for any two of the following]

Require constant fuel supply
Expensive to develop and manufacture
Some require expensive electrolytes or catalysts
Effectiveness affected by impurities in hydrogen fuel
Generate DC current, most household/industry appliances rely on AC current
Not efficient fuel source for transport vehicles due to lack of filling stations able to provide hydrogen fuel, would require large-scale construction of means of storage and distribution