Mark schemes

Q1.

(a) (Ions are) point charges
OR
(Ions are) perfect spheres
OR
No covalent character

Do not accept atoms or molecules in answer
Allow no polarisation of ions

1

(b) $2\ Na^+(g) + 2\ e^- + O(g)$

$2\ Na(s) + \frac{1}{2}O_2(g)$

2

(c) $-416 + \times = 248 + (2 \times 109) + (2 \times 494) - 142 + 844$

enthalpy of lattice dissociation = (+) 2572 (kJ mol^{-1})

−2572 (kJ mol^{-1}) scores 1 mark

2

(d) O^- repels the electron (being added)

Allow negative ion repels electron

1

(e) Oxide ions

M1 have higher (negative) charge
OR
smaller size
OR
higher charge density/higher charge:size ratio (than chloride ions).

M2 stronger attraction between (O^{2-} and Na^+/oppositely charged) ions

Ignore electronegativity

2

(f) Enthalpy of solution = 771 - 406 - 364

= (+)1 (kJ mol^{-1})

Allow 1 mark for -1 (kJmol^{-1})

2

(g) It reacts with water
OR
It reacts to form (a solution of) NaOH

Do not accept - It dissolves in water

1

(h) **M1** T = $\Delta H/\Delta S$

M2 T = $\frac{411}{90.1\times10^{-3}}$ = 4562 (K)

M3 T = 4562 - 273 = 4289 (°C)

M3 = M2 - 273
M3: Allow 4290 (°C)

3

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Q2.

(a) (Enthalpy change = lattice dissociation energy + hydration energies of ions)

M1 Enthalpy change = **+**2237 − (**2** x 364) − 1650

M2 = − 141 kJ mol^{-1}

2

(b) Temperature goes up/increases

Allow answer consequential on (a)

1

(c) M1 fluoride ions/F^- (ions) are smaller

OR

M1 F^- has a higher charge density

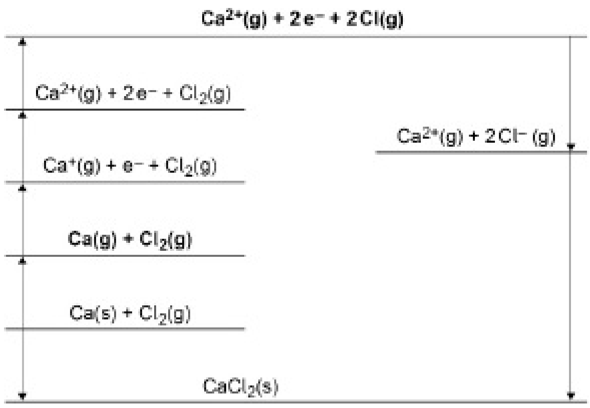
Do not accept fluorine atoms/ions are smaller

M2 stronger attraction (of fluoride ion) to δ+ on H/ electron deficient H (in water)

M2 do not accept ionic bonds
Do not accept more energy to break bonds
Do not accept stronger attraction to H^+
Ignore electronegativity and shielding

2

(d)



2

(e) $-795 = 193 + 590 + 2^{nd}\text{ IE} + (121 \mathbf{\times 2}) + (-364 \mathbf{\times 2}) - 2237$

$= (+)\ 1145\ (\text{kJ mol}^{-1})$

M1: Allow $-795 = -1940 + 2^{nd}$ IE

2

(f) Electron removed from a positive charge/ion

OR

Electron removed from smaller ion/electron removed closer to nucleus

OR

Stronger attraction between same number of protons and fewer electrons

1

(g)

This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.	
Level 3 **5-6 marks**	**All stages are covered and each stage is generally correct and virtually complete.** Answer is communicated coherently and shows a logical progression from stage 1 to stage 2 and stage 3
Level 2 **3-4 marks**	**All stages are covered but stage(s) may be incomplete or may contain inaccuracies OR** **two stages are covered and are generally correct and virtually complete.** Answer is mainly coherent and shows progression from stage 1 to stage 2 and/or stage 3.
Level 1 **1-2 marks**	**Two stages are covered but stage(s) may be incomplete or may contain inaccuracies OR** **only one stage is covered but is generally correct and virtually complete.** Answer includes isolated statements and these are presented in a logical order.
0 marks	Insufficient correct chemistry to gain a mark.

Stage 1 comparing values from perfect ionic model

1a Value for $CaCl_2$ is larger
OR
Values for KCl **and** AgCl are similar
OR
Values for $CaCl_2$ > AgCl > KCl

1b Ca^{2+} has a larger charge/ is a smaller ion
OR
Ag^{+} **and** K^{+} have smaller charge or larger ions

1c $CaCl_2$ has stronger ionic bonds or stronger attraction between + and - ions ($Ca^{2+}$and Cl^{-})
OR
AgCl **and** KCl have weaker ionic bonds or weaker attraction between + and - ions (Ag^{+}/ K^{+} and Cl^{-})

Stage 2 similarities in the perfect ionic model and Born-Haber cycle values

2a $CaCl_2$ has similar values (between the perfect ionic model and Born-Haber cycle)

2b KCl has similar values (between the perfect ionic model and Born-Haber cycle)

2c $CaCl_2$ **and** KCl have (almost) perfect ionic bonding or + ions are point charges/(perfectly) spherical

Stage 3 difference in the perfect ionic model and Born-Haber cycle values

3a AgCl has larger difference in values (between the perfect ionic model and Born-Haber cycle)

3b AgCl contains (some) covalent character

3c Ag^{+} more polarising/distorts electron cloud more

[16]

Q3.

(a) The enthalpy change / ΔH when one mole of a (solid) ionic compound

***Ignore** standard states / conditions*
***Allow** heat change at constant pressure when...*
***Ignore** heat change (alone) / energy change*

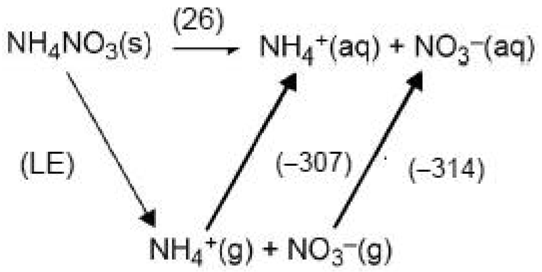
1

dissociates (fully) into gaseous ions

***M2 Allow** suitable equation with state symbols for ions*
***Not** one mole of gaseous ions*

1

(b)



***Allow** + water or +aq*
M1 = cycle (3 'corners' with formulae and state symbols and suitable arrows)
***Allow** equivalent Born-Haber style energy cycle*
***Not** ecf to M2 and M3 from incorrect cycle*

1

LE = 26 + 307 + 314

M2 = working e.g. 26 = LE − 307 − 314

= (+)647

1

M3 = answer (+)647 gets 3/3 if M1 given or 2/3 if not
−647 = 2/3 if M1 given or 1/3 if not
+595 / −595 = 2/3 if M1 given or 1/3 if not
−621/+621 = 1/3 if M1 given
***Not** ecf for M3 from incorrect expression in M2*

1

(c) ($q = mc\Delta T$ =) 25.0 × 4.18 × (20.2 − 12.2) **OR** 25.0 × 4.18 × 8 (= 836 (J) or 0.836 (kJ))

__Not__ if m = 29

__Ignore__ sign of q

1

4.00 g NH_4NO_3 = 4.00/80 **OR** 0.0500 mol

1

ΔH⦵soln = 836/0.05 = 16720 = (+)16.7(2) kJ mol^{-1}

__Allow__ ecf from M1 and/or from M2

–16.7(2) = 2/3

+19.4 = 2/3 (using m = 29 in M1)

−19.4 = 1/3

+2.68 = 2/3

−2.68 = 1/3

+587 or +588 = 2/3

−587 or −588 = 1/3

__Allow__ 2 sig figs or more

1

(d) (2 × 0.1/8) × 100 = 2.5%

__Allow__ ecf from ΔT in (c)

1

(e) use a larger mass/amount of NH_4NO_3 / solid

Marking points are independent

__Allow__ smaller volume of water / less water

__Allow__ use more NH_4NO_3

__Not__ larger volume of water

__Ignore__ higher concentration (of NH_4NO_3)

__Ignore__ any references to changing apparatus e.g. insulation

1

so temperature change/decrease is greater
OR final temperature is lower

__Allow__ temperature increase is greater

__Not__ final temperature is higherr

1

(f) heat gain (from the surroundings) / incomplete dissolvingg

Allow *incomplete reaction*

Allow *thermal energy gain*

Not *heat loss*

Ignore *energy gain*

Ignore *references to mistakes in method*

1

(g) ΔS = (113 + 146) − 151 = +108 (J K^{-1} mol^{-1})

1

$\Delta G = \Delta H - T\Delta S$ **OR** 26 − (298 × 108 × 10^{-3})

Allow *ecf 26 − (298 × M1 × 10^{-3})*

Allow *ecf 26 − (298 × M1)*

Allow M2 *for 26000 − (298 × 108)*

Allow M2 *for 26 − (298 × 108)*

1

ΔG = −6.184 / −6.18 / −6.2

−32158 = ***M1*** *and* ***M2***

−32.2 = ***M1*** *and* ***M2***

−6184 = ***M1*** *and* ***M2***

(+)58.2 = ***M2*** *and* ***M3*** *(ecf if −108 for M1)*

1

negative value for ΔG indicates reaction is feasible/spontaneous

Allow *positive value for ΔG indicates reaction is NOT feasible/spontaneous*

Allow *< 0 or > 0 as appropriate*

M4 *is standalone*

1

(h) Converting ΔH into J **OR** ΔS into kJ

1

($T = \Delta H/\Delta S$ = 123/144 × 10^{-3} **OR** 123000/144) = 854(.1666666) (K)

0.854 (K) = 1/2

0.00117 (K) = 1/2 (calculation upside down)

2SF minimum

1

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