M1.(a) **In either order**

For M1 accept [ ] for concentration

M1 <u>Concentrations</u> (of reactants and products) <u>remain or stay constant</u> / the same
NOT "equal concentrations" and NOT "concentration(s) <u>is /</u>
<u>are</u> the same"

M2 <u>Forward rate</u> = <u>Reverse / backward rate</u>
NOT "amount"
Ignore "dynamic" and ignore "speed"
Ignore "closed system"
It is possible to score both marks under the heading of a single feature

2

(b) **M1** Catalysts <u>increase rate of / speed up</u> both <u>forward and reverse / backward</u>
<u>reactions</u>
If M1 is given as "no effect" / "no change" then CE= 0 for clip

M2 increase in <u>rate</u> / affect on <u>rate / speed</u> is <u>equal / the same</u>
Ignore references to "decrease in rate"

2

(c) **(i)** **M1** (The yield) <u>increases</u> / goes up / gets more
If M1 is given as "decreases" / "no effect" / "no change" then CE= 0 for clip, but mark on from a blank.

M2 There are <u>more moles / molecules</u> (of gas) on the <u>left</u> / of reactants
Ignore "volumes", "articles" "atoms" and "species" for M2

OR <u>fewer moles / molecules</u> (of gas) on the <u>right</u> / products

OR there are <u>4 moles / molecules</u> (of gas) on the left <u>and 2 moles</u>
<u>/</u>   <u>molecules</u> on the right.

OR (equilibrium) shifts / moves <u>to the side with less moles / molecules</u>

M3 Can only score M3 <u>if M2 is correct</u>

The <u>equilibrium shifts / moves</u> (from left to right) to <u>oppose the increase</u>
<u>in pressure</u>
For M3, <u>not</u> simply "to oppose the change"
For M3 credit the <u>equilibrium</u> shifts / moves to <u>lower /</u>
<u>decrease</u> the <u>pressure</u>
(There must be a <u>specific</u> reference to the change that is opposed)

3

(ii)   **M1**   The yield decreases / goes down / gets less

If M1 is given as "increase" / "no effect" / "no change" then
CE= 0 for clip, but mark on from a blank.

     M2   (Forward) reaction is <u>exothermic</u> *OR* <u>gives out / releases heat</u>

     OR

     reverse reaction is <u>endothermic</u> *OR* <u>takes in / absorbs heat</u>

Can only score M3 <u>if M2 is correct</u>

The <u>equilibrium shifts / moves</u> (from right to left) to <u>oppose the increase in temperature</u>

     For M3, <u>not</u> simply "to oppose the change"
     For M3 credit the <u>equilibrium shifts / moves</u>
     to <u>absorb the heat</u> OR
     to <u>cool the reaction</u> OR
     to <u>lower the temperature</u>
     (There must be a <u>specific</u> reference to the change that is opposed)

                                                    3

(d)   (i)   Must be comparative

     Credit correct reference to rate being <u>too (s)low / (s)lower</u> at temperatures less than 600 K

<u>Higher rate</u> of reaction

OR <u>increase / speed up the rate</u> (of reaction)
     Ignore statements about the "yield of ammonia"

OR Gets to equilibrium <u>faster/ quicker</u>

OR <u>faster or quicker rate / speed</u> of attainment of equilibrium

                                                    1

     (ii)   <u>Less</u> electrical <u>pumping cost</u>
     Not just "less expensive" alone

     OR

     Not just "less energy or saves energy" alone

Use lower pressure <u>equipment / valves / gaskets / piping</u> etc.
     Credit correct <u>qualified</u> references to higher pressures

     OR

Uses less expensive <u>equipment</u>
     Ignore references to safety

1

[12]

M2.   **(a)**   Forward and backward reactions proceeding at equal rate

1

Amount (Conc or moles or proportion) of reactants and products remain constant

Not "reactants and products have equal conc"

1

(b)   **M1** $\dfrac{[R]^2}{[P][Q]^2}$

Allow ( ) but must have all brackets
*If Kc wrong can only score **M3** (process mark) for dividing both R and P by volume)*

1

(c)   **M2** $[Q]^2 = \dfrac{[R]^2}{k_c[P]}$

Rearrangement of correct Kc expression
*If wrong Kc used can only score **M3** for correct use of vol*
*If wrong rearrangement can only score max 2 for **M3** and **M5** for correct √*

1

M3 $[Q]^2 = \dfrac{(5.24/10)^2}{68.0 \times (3.82/10)}$

Process mark for dividing both R and P by volume even in incorrect expression
*If vol missed can only score max 2 for **M2** and **M5** for correct √*
*If vol used but then wrong maths can score **M2 M3** and **M5** for correct √*
*If moles used wrongly, eg (2 × 5.24) or (5.24 × 10/10⁹) can only score **M2** and **M5***

1

M4 $[Q]^2 = 0.0106$

        Correct calculation of Q^2

        1

M5 $[Q] = 0.10(3)$

        Correct taking of $\sqrt{}$

        1

(c)   cont.

Wrong rearrangement and no use of volume

        0

Wrong rearrangement

        For Correct use of volume **M3** *and Correct taking of square root* **M5**

        2 max

No use of volume

        2 max

        answer = 0.325

        Ignore subsequent multiplying or dividing by 10.

        0.0325 or 3.25 *still score max 2*

        For Correct rearrangement **M2** *and*

        Correct taking of square root **M5**

        2 max

Use of volume but maths error e.g. using $(5.24)^2/10$
when should be $(5.24/10)^2$

        Scores 3

        also giving answer **0.325**

        for **M2**, **M3** *and* **M5**

        3

Use of volume but Q/10 also used
or Q multiplied by 10 at end
(i.e. muddling moles with concentration)

        Gives answer 1.03

        For Correct rearrangement **M2** *and*

        Correct taking of square root **M5**

        2 max

Wrong use of moles, e.g (5.24×2) or $(5.24 \times 10/10^3)$

        For Correct rearrangement **M2** *and*

        Correct taking of square root **M5**

        2 max

Wrong Kc used, e.g. missing powers
*For Correct use of volume **M3***

1 max

(d)   Increase or more or larger
        Allow moves to left

1

(e)   Increase or more or larger
        Allow moves to left

1

(f)   Decrease or less or smaller
                NOT allow moves left

1

(g)   No effect or unchanged or none

1

(h)   0.0147 or 0.0148 or 1.47×10^{-2} or 1.48×10^{-2}

Allow 0.015 or 1.5×10^{-2}

If not 0.0147, look at (c) for conseq correct use
of their [Q] in new Kc = $1.39 \times [Q]^2$
                Not allow just 1/68.0
                ignore units

1

[24]

M3.   (a)   (i)   **M1**   The peak of the new curve is <u>displaced to the right</u>.

                M2   All of the following are required

                •   The new curve starts at the origin

                •   The peak of the new curve is <u>lower</u> than the original

                •   <u>and</u> the new curve only crosses the original curve <u>once</u>

                •   <u>and</u> an attempt has been made to draw the new curve

correctly towards the energy axis but not to touch the
original curve

- the new curve must not start to diverge from the original curve
  M1 is low demand
  M2 is higher demand.

2

(ii)   **M1**   Increase in the number/proportion of molecules with $E \geq E_a$

      OR   more molecules have $E \geq E_a$

      OR   more molecules have sufficient energy to react

      M2   More effective/productive/successful collisions
             Ignore "molecules have more energy"
             Ignore "more energetic collisions"
             Ignore "molecules gain activation energy"
             Ignore "more collisions"
             Accept "particles" for "molecules" but NOT "atoms"
             Ignore "chance of collision"; this alone does not gain M2

2

(b)   (i)   Iron *OR* Fe

1

(ii)   **M1**   Catalysts provide an alternative route/pathway/mechanism

      OR

      (in this case) surface adsorption/surface reaction occurs.
             For M1, not simply "provides a surface" alone

      M2   that has a lower activation energy

      OR

      lowers the activation energy
             *For M2, the candidate may use a definition of activation
   energy without referring to the term*

2

[7]

M4.   **(a)**   <u>Heat (energy) change at constant pressure</u>

          Ignore references to standard conditions, but credit specified pressure.

          1

    (b)   The <u>enthalpy change/heat (energy) change</u> (at constant pressure) in a reaction is independent of the route/path taken (and depends only on the **initial** and **final** states)

          1

    (c) $\Delta H + 963 = -75 - 432$ OR $\Delta H + 963 = -507$ **(M1)**

        $\Delta H = -75 - 432 - 963$ **(M1 and M2)**

        $\Delta H = \underline{-1470}$ (kJ mol^{-1})

        Award 1 mark for + 1470

               <u>Award full marks for correct answer</u>
               Ignore units.
               Ignore numbers on the cycle
               ***M1** and **M2** can score for an arithmetic error*

          3

          [5]

M5.(a)   Hydrogen bonding / hydrogen bonds / H-bonding / H-Bonds

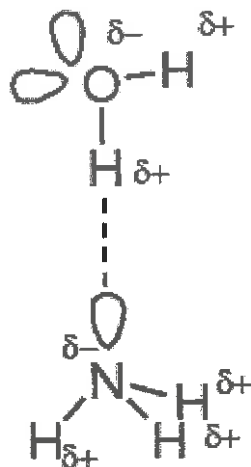   *Not just hydrogen.*

          1

    (b)
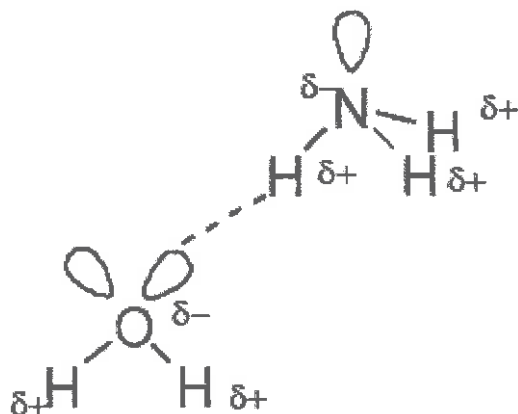
One mark for minimum of 4 correct partial charges shown on the N-H and O-H
One mark for the 3 lone pairs.
One mark for H bond from the lone pair on O or N to the H⁺

OR

The N-H-O should be linear but can accept if the lone pair on O or N hydrogen bonded to the H
If wrong molecules or wrong formula, CE = 0/3

3

(c)   (Phosphine) does not form hydrogen bonds (with water)

1

[5]

M6.   *Ideal gas equation:* pV = nRT **(1)**

Calculation: n = pV/RT = $\dfrac{103000 \times 127 \times 10^{-6}}{(8.31 \times 415)}$ **(1)**

mark for volume conversion fully correct

= 3.79 × 10⁻⁵ (mol) **(1)**

range 3.79×10^{-3} to 3.8×10^{-3}

$M_r = m/n = .304/3.79 \times 10^{-3} = 80.1$ **(1)**

range 80 – 80.3
min 2 s.f. conseq
If 'V' wrong lose M2; 'p' wrong lose M3; 'inverted' lose M3 and M4

[5]

M7.A

[1]

M8.D

[1]

M9. Divides percentage by price

Ratios are 1.668, 1.701 and 1.437

Dub-Lit Brick Cleaner is the best value

Allow if divides price by percentage (ratios are 0.600, 0.588 and 0.696).

Lose mark if no working shown or contains an arithmetic error.

[1]

M10.A

[1]