Q1.

5 (a) **(i)** haem; R. incorrect spelling
combines/binds with/carries/holds/takes up/transports oxygen; **2**

(ii) soluble/polar/hydrophilic (on outside)/compact/spherical/curled/coiled/folded (into a ball)/metabolically active;
4 polypeptides; **2**

(b) iron needed for haem/haem contains iron;
less haemoglobin (made); R. less RBCs
less oxygen transported/supplied/delivered (to cells/tissues);
less respiration/respiration rate decreased;
R.respiration less efficient/effective **max 3**

(c) muscle; A. cardiac/skeletal/involuntary muscle **1**
R. named muscle, e.g. biceps muscle

(d) **(i)** 90%;
25%; A. within range 23-25% R. 23-26%, 22-25%
(N.B. Both % need to be correct for one mark) **1**

(ii) haemoglobin unloads/releases oxygen/dissociates,
easily/readily/at higher ppO_2 (in tissues/cells);
(whilst) myoglobin holds on to oxygen/is very stable/does not dissociate easily/has a higher affinity for oxygen;
(so) providing a store/reservoir/reserve of oxygen;
(so will not) release oxygen until the pp/conc./tension of oxygen is low/during strenuous exercise;
so delaying anaerobic respiration; **max 3**

(e) S-shaped curve to the right of **H**;
(N.B. curve should be S-shaped, start at 0, plateau out at between 90-98% saturation, show 50% plus saturation at pp of 6kpa) **1**

[Total 13]

Q2.

Question	Expected Answers	Marks
1 (a)	P - right atrium / auricle; **R** atrial Q - aorta;	2
(b)	more muscle in wall of S; ora S / left ventricle, (pumps) blood, around whole body / further; R / left atrium, (pumps) blood to ventricle / short distance; (wall must resist) high(er) pressure in S / needs to overcome greater resistance to flow;	2 max
(c)	myogenic; SAN, is pacemaker / sends out impulses / waves of excitation / initiates, heart beat / action potential / contraction; **R** electrical, messages / waves / signals AVN delays, impulse / contraction (of ventricles); detail e.g. specific time ref (0.1 - 0.2 secs) *or* to allow ventricles to fill / atria to empty; relays impulse to Purkyne tissue / bundle of His; Purkyne tissue conducts (impulse) to base / apex of heart / septum / ventricles; ref to papillary muscles contracting; ventricle (muscle) contracts / ventricular, contraction / systole, from base upwards; (blood) into arteries / named artery;	4 max
(d)	fat / cholesterol / deposited in, plaque / atheroma formed in, wall / endothelium / epithelium / lining, of artery; **R** dead cells • (so) narrows lumen of artery; • (so) blood flow reduced / restricted (in coronary arteries); **R** constricted / stop (this) creates higher blood pressure; less oxygen / glucose, supplied to heart muscle; **R** no oxygen **A** blood sugar less wastes removed; anaerobic respiration; build up of lactic acid; fibrillation / heart muscle contracts less strongly; angina / CHD / heart attack / MI / heart failure; • (risk of), thrombosis / clot / thrombus; cardiac, cell / tissue / muscle, death; • *(award only if linked to deposition of fat / plaque formation not sticky platelets)*	4 max **[Total: 12]**

Q3.

(c) *assume answer is about red blood cells unless indicated otherwise*

no nucleus;
no cell wall;
no vacuole; **R** smaller vacuoles
no, organelles / named organelle visible in fig. 4.1;
A only chloroplasts / mitochondria / ribosomes
R refs to shape **3 max**

(d) partial pressure of oxygen is low; **A** low concentration / lack / less of oxygen / ora
more haemoglobin (is produced);
idea of compensating / making up for / counteracting the smaller volume of oxygen absorbed / lower saturation of haemoglobin / haemoglobin only 70% saturated / less oxygen carried around body; **2 max**

Q4.

3 (a) 4 polypeptides/4 globins/4 amino acid chains;

outwardly pointing hydrophilic (R) groups, maintain solubility/AW;

each with a haem group;

ref to iron/Fe^{2+} (ion); **R** Fe^{3+}/iron atom

temporary attachment to oxygen; **A** readily attaches/binds combines with
R oxygen binds to haem

4 molecules of oxygen; **A** 4 O_2/8 oxygen atoms **R** 4 oxygens unqualified

oxyhaemoglobin; **A** HbO_8

ref to cooperative binding; **[max 4]**

(b)

part of the circulation	partial pressure of oxygen/kPa	% saturation of haemoglobin
capillaries in the lungs	accept answers between 12 and 14;	
capillaries in muscle tissue at rest	5;	
capillaries in muscle tissue during strenuous exercise	20;	

[3]

(c) carbon dioxide reacts with water to form carbonic acid;

catalysed by carbonic anhydrase;

dissociates to hydrogen carbonate and hydrogen ions;

hydrogen ions combine with haemoglobin; **R** hydrogen ions replace oxygen in haemoglobin

forms haemoglobinic acid/HHb;

so releasing oxygen;

ignore ref to Bohr shift (question says 'explain')

A from equations. **[max 3]**

[Total: 10]

Q5.

1 (a)

	cell **A**	cell **B**	cell **C**
name of cell	phagocyte / neutrophil / AW;	squamous epithelial (cell) / endothelial (cell);	
function of cell			transports, oxygen / carbon dioxide;
diameter / µm	*to be added*		

[4]

(b) **D** mitochondrion;
E lysosome / (Golgi) vesicle; **R** vacuole
F nucleus; **[3]**

(c) *oxygen*
diffuses, down concentration gradient / from high concentration to low concentration;
through, phospholipid bilayer; **R** protein channels

glucose
(pressure) filtration / AW; e.g. 'forced out by blood pressure'
through pores, in capillaries / between capillaries;

facilitated diffusion;
through channel proteins / idea;
through cytoplasm; **[max 3]**

(d) *assume answer is about vein unless told otherwise*

thicker wall / more cells / more than one cell thick;
A more, squamous epithelium / endothelium
valve(s);

three layers / described;

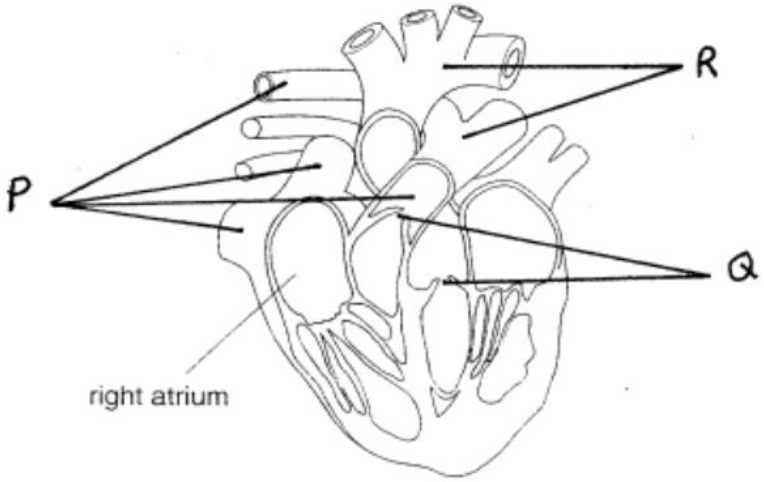
to max 2
(smooth) muscle;
collagen;
elastic tissue / elastin;

R references to size, width, size of lumen, amount of blood etc. **[max 3]**

[Total: 13]

Q6.

1 **(a)** *accept without label lines if not ambiguous e.g. if written correctly on diagram*
*only accept more than one line for each if **all** are correct*



[3]

(b) (both) atria pump blood to ventricles ;
same / short, distance ;

right ventricle pumps blood to lungs ;
short distance / at low(er) pressure / at approx 3.2 kPa / at approx 24 mmHg ; ora i.e. (left ventricle) greater distance / high(er) pressure / at approx 15.8 kPa / at approx 120 mmHg
less resistance, in lungs *or* pulmonary circulation / greater resistance in the systemic circulation ;
left ventricle pumps to, whole body / AW ;
correct ref. to (muscular) walls ; e.g. same (thickness) in atria
thicker / thinner, in ventricles
more / less, muscular, in ventricles
right ventricle pumps with lower / less, force ; **ora** [4 max]

(c) *accept once only for either nicotine or carbon monoxide*
damages lining of arteries ;
promotes, atheroma / atheromatous plaques / fatty plaques / arteriosclerosis / atherosclerosis ;

nicotine
increases heart rate ;
increases blood pressure ;
makes platelets 'sticky' ;
increases chance of blood clotting / promotes thrombosis ;
decreases flow of blood to, extremities / AW ;
constriction of blood vessels ; **R** contraction **R** capillaries (2 max)

carbon monoxide
combines with haemoglobin / forms carboxyhaemoglobin / higher affinity for haemoglobin (than oxygen); **R** absorbed, reacts with, bonds to
reduces oxygen carrying capacity (in context of, haemoglobin / blood) ;
promotes release of damaging free radicals / peroxides / super oxides / oxidising agents ;
causes platelets and neutrophils to stick together / platelets to stick to endothelium ;
hypoxia can damage heart muscle ; (2 max) [4 max]

[Total: 11]

Q7.

3 **(a)** **(i)** right ventricle ;
pulmonary vein ; [2]

(ii) *ignore close to prevent backflow – allow ref to one side only*
valve opens to allow blood from atria to ventricles ;
when ventricles contract, valves close (to stop backflow) ;
A valves close when blood is pumped out of the ventricles
ref. to pressure difference between chambers ; [2 max]

(b) 1 ;
5 ;
2 ;
4 ; [4]

(c) 1 SAN sends out, wave of excitation / impulses ; **A** electrical (im)pulses
R once only - nervous impulse(s) / pulse(s) / signal(s) / wave(s)
R if brain stimulates SAN to send out impulses
2 spreads across atria ;
3 atria contract / atrial systole ;
4 fibrous ring / non-conducting tissue / insulating tissue ;
5 prevents, it reaching the ventricles / ventricles contracting at the same time (as atria) ;
6 AVN sends on wave of excitation to ventricles ;
A *in context – impulse reaches AVN and is passed on to ventricles*
7 (therefore) time delay to allow, atria to empty / atria to complete contraction / ventricles to fill / atria and ventricles do not contract at the same time ;
8 time ref. 0.1–0.2 seconds ;
9 Purkyne tissue conducts, excitation / impulses, to base of, septum / ventricles ;
A apex of heart
10 spreads upwards in ventricle (walls) ;
11 (so) ventricles contract from base upwards / ventricles force blood up from base ;
[5 max]

[Total: 13]

Q8.

2 **(a)** **(i)** right, atrium/auricle **and** left ventricle ; *correctly labelled*
left hand side box *right hand side box* [1]

(ii) *right atrium has* *(ora for left atrium)*

lower, concentration/partial pressure/AW, of, oxygen ; **R** no oxygen
A (right) deoxygenated blood (versus oxygenated blood)
A higher saturation of haemoglobin with oxygen

higher concentration/AW of, hydrogen carbonate ions/carbon dioxide ;
A more carbaminohaemoglobin

higher concentration of water molecules/high(er) water potential/less negative water potential ;

higher concentration/AW, of glucose ; [2 max]

(b) *reject if more than one letter for each disease*
pulmonary stenosis = **G** ;
coarctation of the aorta = **D** ;
ventricular septal defect = **F** ; [3]

(c) *accept ora where relevant*

suggest
1 blood flows from aorta to pulmonary artery ;
2 increased volume of / more, blood to lungs ;
A blood to lungs at higher pressure
3 oxygenated and deoxygenated mix ;
4 oxygenated blood / blood from aorta, to lungs ;

explain (why blood flows from aorta to pulmonary artery)
5 left ventricle thicker wall (than right ventricle) ;
6 (so) contraction generates greater force (than right ventricle)/AW ;
7 higher pressure in aorta (than pulmonary artery) ; [3 max]

[Total: 9]

Q9.

2 **(a)** semilunar valve ; **A** pulmonary valve

prevents backflow (of blood) ;
from the pulmonary artery/into the right ventricle ;
or
ensures one-way flow of blood ;
from the right ventricle/into the pulmonary artery ; [3]

(b) (**Y**/wall of left ventricle) contains more (cardiac) muscle ; ora
left ventricle/ventricle beside **Y**, pumps blood to, whole body / further ; ora
at higher pressure with more force (than right) ; ora
resistance to blood flow is greater in systemic circulation ; ora [3 max]

(c) *any two of* SAN, AVN, Purkyne tissue/Bundle of His *in correct context* ;

SAN/(primary) pacemaker, sends out, waves of excitation/impulses ;
A electrical (im)pulses
R once only nervous impulse(s)/pulse(s)/signal(s)
R if brain stimulates SAN to send out impulses
spreads across atria ;
atria contract/atrial systole ;

fibrous ring/non-conducting tissue/insulating tissue ;
prevents, it reaching the ventricles/ventricles contracting at the same time (as atria);

atrio-ventricular node/AVN, acts as 'relay station'/sends wave of excitation to ventricles;
A in correct context – impulse reaches AVN and is passed on
(therefore) time delay to allow, atria to empty/atria to complete contraction/ventricles to fill//
atria and ventricles do not contract at the same time ;
time ref. 0.1 – 0.2 seconds ;

Purkyne tissue bundle of His, conducts, excitation/impulses, to base of, septum/ventricles ;
A apex of heart
spreads upwards in ventricle (walls) ;
(so) ventricles contract from base upwards/ventricles force blood up from base ; [5 max]

[Total: 11]

Q10.

2 **(a)** diffusion / diffuses ;
down concentration gradient / from high concentration to low concentration / from high to low partial pressure ;
description of pathway ;
two of the following
cell (surface) membrane of (respiring) cell, tissue fluid, (pore in) capillary wall / endothelium / endothelial cell, basement membrane / plasma [max 2]

(b) *assume answer refers to Y unless told that it refers to X*
less pressure ; **A** low pressure
less oxygen ; **A** deoxygenated
less glucose ; *only accept more glucose if identified as liver*
fewer / more, amino acids / fatty acids ;
less water / lower water potential / lower solute potential / higher osmotic pressure / higher concentration of solutes *and / or* rbcs ;
A 'blood is more concentrated'
fewer ions ;
more of **named** cell product ; e.g. insulin / glucagon / albumen / AW

(more), urea / excretory waste ; **R** waste unqualified [max 3]

(c) (i) carbonic anhydrase ; [1]

(ii) (catalyses very) fast / AW, reaction ;
(carbon dioxide as) hydrogen carbonate ions / bicarbonate ions ;
diffuse / move / leaves, out of the (red blood) cell ;
in(to) the plasma ; **R** 'into blood'
(so that) blood can transport more than could be transported as carbon dioxide (in solution) / 80 – 90% CO_2 transported this way ;
idea that
reaction maintains concentration gradient for CO_2 from, tissues / tissue fluid, to blood ;
if carbon dioxide transported then pH would decrease ;
(therefore) maintains pH / prevents pH decreasing / acts as a buffer ; [max 3]

(d) (i) 55 (%) **A** 54 - 56 (%),
32 (%) **A** 31 / 31.5 (%) ; [1]

(ii) hydrogen ions / protons ; **A** H^+
either
react *or* combine with haemoglobin / form haemoglobinic acid / form HHb ;
A 'picks up' / absorb
or
carbon dioxide combines with haemoglobin / forms carboxyhaemoglobin ;
(so) stimulate haemoglobin to release more oxygen (in areas of low pO_2) ;
ref. to, allosteric effect / change in tertiary *or* quaternary structure *or* shape ;
A conformational change
either
haemoglobin has a higher affinity for hydrogen ions than oxygen = 2 marks
or
haemoglobin has a higher affinity for carbon dioxide than oxygen = 2 marks [max 2]

(iii) Bohr (effect / shift) ; [1]

(iv) **1** carbon dioxide influences percentage saturation of haemoglobin with oxygen / AW ;
2 tissues / cells, with high rate of (aerobic) respiration ;
3 high demand for oxygen ;
4 haemoglobin / blood, releases more oxygen ; **R** faster
5 than it would in absence of carbon dioxide ;
6 at same partial pressure of oxygen ; [max 3]

[Total: 16]

Q11.

3 (a) **1** small size / 6-8 μm (diameter), to squeeze through capillaries (7 μm) ;
2 small size / 6-8 μm (diameter), so, haemoglobin (molecules) near to surface (of plasma membrane) / reduces distance for diffusion (in / out of rbc) ;
3 no nucleus / lack of organelles, so more room for haemoglobin (so more oxygen transported) ; **R** more room for oxygen
4 biconcave shape / diagram drawn, increases surface area for, diffusion / uptake / release (of oxygen) ;
5 flexible / AW (membrane), to squeeze through capillaries ; [max 3]

(b) **1** enzymes are proteins, protein synthesis does not occur ;
2 no, nucleus / DNA / genes, so no, transcription / mRNA ; } *
3 no mRNA, so no, translation / protein synthesis ; }
***A** no nucleus, so no protein synthesis *for one mark*
4 no, RER / ribosomes, site of protein synthesis / AW ;
5 no mitochondria, insufficient ATP (for synthesis) ;
6 no RER for modification (of protein) ; **A** Golgi apparatus [max 2]

(c) **(i)** iron ; **A** Fe^{2+} / Fe^{3+} / ferrous / ferric [1]

(ii) amino acids / peptides ; [1]

(d) carbonic anhydrase ; [1]

(e) **1** diffusion of, carbon dioxide / CO_2;
2 into red blood cell from correct source ;

3 description of carbonic acid formation followed by H^+ production ;
4 ref. carbonic anhydrase) fast reaction; **A** ecf from **(d)**

5 haemoglobin has a higher affinity for hydrogen ions than oxygen ;
A haemoglobin releases oxygen more easily in acidic conditions
accept idea of H^+ binding to haemoglobin bringing out oxygen release
6 ref. to, allosteric effect / change in tertiary structure / AW, in (oxy)haemoglobin, causes, release / AW, of oxygen ;
7 formation of haemoglobinic acid ; *must refer to, H^+ binding / decreased pH*
8 ref. higher partial pressures / AW, CO_2, linked to (oxy)haemoglobin releasing, more oxygen / oxygen more readily ; *Bohr shift*
9 formation of carbamino-haemoglobin ; **R** carboxyhaemoglobin

10 chloride shift, qualified ;
e.g. as hydrogen carbonate ions move out of cell, chloride ions move in e.g. to maintain, electroneutrality / a balance of charge / ions ; [max 5]

[Total: 13]

Q12.

4 **(a)** **(i)** red blood cells / erythrocytes / red blood corpuscles ; [1]

(ii) *myoglobin* 78% **A** 77% } ;
haemoglobin 21% } *must have both correct for 1 mark* [1]

(iii) myoglobin has higher affinity for oxygen / myoglobin binds oxygen while haemoglobin releases oxygen ; ora
(myoglobin) acts as a store of oxygen ;
myoglobin will only release oxygen, at (very) low oxygen partial pressures / AW when oxygen demand (in muscles) exceeds supply ; **A** during exercise
AVP ; e.g. myoglobin has, one / fewer haem groups, so no cooperative binding effects
e.g. allows aerobic respiration to continue (in muscle) [max 2]

(b) **(i)** fetal haemoglobin has higher oxygen affinity (than adult / maternal haemoglobin) / AW ;
(higher oxygen affinity) over all ppO_2 / use of data at more than one ppO_2 (from Fig. 4.1) ;

oxygen uptake from, adult / maternal, blood / AW ;
or
gas exchange taking place between fetal and, adult / maternal, blood ;

ref. to fetal reliance on mother to supply oxygen / mother only source of oxygen for fetus ; [2]

(ii) at lower ppO_2 both, unload / AW, oxygen ;
sufficient / more, adult haemoglobin present or adult haemoglobin provides sufficient oxygen / AW ;
ref. to compensating by producing additional red blood cells ;
AVP ; e.g. ref. to similarity of position of both curves [max 1]

(c) (all) to the right of given curve, same overall shape as adult haemoglobin curve ;
to the right of given curve, begins at 0.2 kPa, ends at 97% ;
A *within range of* 0–0.4kPa and 95–99% [2]

[Total: 9]

Q13.

3 (a) (i) *no mark if no units used at all*
L – 3.6 kPa ; *award the mark if units only used once*
M – 4.5 kPa ; **A** in range 4.45 to 4.55 [1]

(ii) *ignore any similarities*
1 to the right / lower (affinity) / qualified ; e.g. lower percentage saturation
2 at, higher / lower, partial pressures, small(er) difference in percentage saturation (than others) ; **A** ora
3 comparative data quote ; *must refer to **L** and **M***
allow ecf from (i) [3]

(b) 1 at partial pressures in the tissues ; *where oxygen is unloaded from Hb*
2 haemoglobin is less saturated (than **L**) ;
3 because, haemoglobin / Hb, dissociates more readily ;
A idea of unloading oxygen more readily *even if Hb not mentioned*
4 to compensate for, fewer / less effective, red blood cells / Hb ; [max 3]

(c) 1 haemoglobin less well saturated (in lungs at high altitude) ;
2 data quote from Fig. 3.1 ; **A** 80–90% saturated at 'about 7.5 kPa'
3 produce more red blood cells / increase in number of RBCs ;
4 more haemoglobin ;
5 *idea* of compensates for, smaller volume of oxygen absorbed / lower saturation (of haemoglobin) ;

also accept the following adaptations
6 increase in haematocrit / AW / decrease in plasma volume ;
A increase in RBCs per unit volume
R decrease in blood volume
7 increase in, breathing rate / tidal volume / heart rate / stroke volume ;
8 increase in, capillary density / number of mitochondria / myoglobin / respiratory enzymes, in muscle ;
9 ref. to (increased) secretion of, erythropoietin / EPO ;
10 increase in (2,3), BPG / DPG, in red blood cells ; **A** rightward shift in curve [max 4]

(d) 1 not caused by (named type of) pathogen / non-infectious / non-transmissible / non-communicable / AW ;
2 genetic / inherited / AW, disease ; **A** caused by a mutation / AW
A 'passed down from parent(s)'
R idea of congenital diseases
R 'you get it from your mother'
3 ref. to, no immune response / no antigen(s) ;
4 affects all red blood cells so vaccine would lead to their destruction ; [max 2]

[Total: 13]

Q14.

1 **(a)** capillary ;

plus one of
ref. to size relative to size of red blood cell (in lumen) ; **A** small diameter / narrow lumen *if capillary correctly identified*
(wall is) one cell thick ; **A** ref. to, only one layer / only endothelium / thin endothelium
[max 2]

(b) (i) red blood cell / erythrocyte ; **A** red blood corpuscle [1]

(ii) water ; **A** plasma [1]

(iii) nucleolus ; **A** nucleus [1]

(c) *if working shown, award one mark only if measurement is incorrect*
7 (μm) ;;

one mark if correct working is shown but answer not to whole number or incorrect conversion used
39 mm / 6000 **A** ± 1 mm in measurement [2]

[Total: 7]

Q15.

1 **(a) (i)** **A –** endothelial / squamous / epithelial (cell) ;
B – nucleus ; [2]

(ii) 7 (μm) ;;
award two marks if correct answer given
award one mark if not rounded to nearest whole number
award one mark if given incorrect unit
if no answer given, award one mark if correct measurement (38–41 / 3.8–4.1 / 38000–41000) is divided by 5700 [2]

(iii) *for two marks - one structure and one function*
only two functions = 1 mark
only two structures = 1 mark

1 (capillary) wall is, thin / single layer of cells / one cell thick ;
A endothelium / epithelium for wall
2 short diffusion, pathway / distance / AW ;
R 'easy' diffusion
3 (many have) endothelial pores / fenestrations / gaps / spaces / openings ;
4 to allow named, substance / cell, to leave the blood ;
A *idea* of separation / selection, of named substance(s) by size
5 small diameter / small lumen / diameter of red blood cells ;
6 slows down flow of red blood cells / (capillary / blood) close to cells ;
7 (capillaries have) large, surface area / surface area to volume ratio ;
8 *idea that* allows more exchange ;
Ignore faster exchange [max 2]

(b) *white blood cells*

1 (named) white blood cells can, leave capillaries / enter tissue fluid ;
A diapedesis / (suggestion that some) too large to leave the, blood / capillaries

2 high number in, lymph nodes / thymus / bone marrow / spleen ;
A stored / produced

glucose

3 small (molecule) ;

4 filtered / diffuses / leaves / leaks, from blood / from capillaries / into tissue fluid ;

5 taken up / used, by cells in respiration ;
Ignore supply

protein

6 too large to, leave capillaries / enter lymph / enter tissue fluid ;

7 (in lymph / tissue fluid) antibodies / proteins, from / secreted by, lymphocytes / other cells ; [max 5]

(c) *accept hydrogen carbonate (ions) / bicarbonate (ions) / HCO_3^- penalise HCO_3 once only*

1 carbon dioxide, reacts / combines, with (terminal amine / **N** terminal, of) haemoglobin ;
R carried by / reacts with, haem

2 to form carbaminohaemoglobin ;

3 carbonic anhydrase catalyses, formation of carbonic acid (H_2CO_3) / reverse reaction described (in the lungs) ;

4 (carbonic acid dissociates to) HCO_3^- / CHO_3^- / hydrogen carbonate (and H^+) ;

5 hydrogen carbonate / HCO_3^-, diffuses / moves / AW, out (into plasma) ; [max 3]

[Total: 14]

Q16.

6 **(a)** *all correct* ;;;

event	*sequence*
Purkyne tissue conducts the wave of excitation	4
atrioventricular node sends out a wave of excitation	3
atria contract	2
ventricles contract	5
sinoatrial node sends out a wave of excitation	1

if not correct sequence, mark to max 2
SAN = 1 ;
atria contract before ventricles ; [max 3]

(b) left ventricle pumps blood to the body, right ventricle pumps blood to the lungs ;
(left) round the body further distance / (right) to lungs shorter distance ; AW
(left) greater force required / (right) less force required ; **A** (left) blood needs to be pumped at a higher pressure / (right) blood needs to be pumped at a lower pressure
A needs to overcome greater resistance
less force / lower pressure, to lungs, to prevent damage to capillaries ; [max 2]

[Total: 5]

Q17.

1 (a) thicker wall;
smaller / narrower lumen;
more muscle / more elastic tissue / more / thicker tunica media;
ref to 'crinkly' / crenulated / wavy / folded, lining / endothelium / tunica intima; R. epithelium
ref to wall to diameter ratio e.g. thicker wall to diameter ratio;
more collagen fibres / more tunica adventitia / externa;
circular / rounded shape compared to irregular shape;
A. converse points for vein

max 3

(b) provide a large surface area / surface area to volume ratio;
for gas exchange / carbon dioxide out and oxygen in;
short diffusion distance across capillary wall / one cell thick capillary wall / 1-2µm c. wall / thin endothelium;
R. epithelium R. thin wall unqualified
small size enables blood to be as close as possible to lung cells / air in alveolus / capillaries in close contact with alveolus (wall);

(so) diffusion is efficient / takes place easily / maximises efficiency of diffusion;

max 3

(c) destroys / paralyses / inhibits / weakens cilia; R. kill
mucus glands / goblet cells produce more mucus;
tar contains carcinogens / chemicals which damage DNA / genes / oncogenes;
ref cancer / tumour;
epithelium / lining replaced by scar tissue;

max 3

[Total 9]

Q18.

4 **(a)** *Double* – blood passes through the heart twice during one circulation;
Closed – blood travels inside blood vessels. **[2]**

(b) *One mark for an advantage and one mark for a disadvantage.*

Advantage
More space, for haemoglobin/to carry oxygen;
Idea that rbcs can change shape, to fit through capillaries.

Disadvantage
Cannot carry out, protein synthesis/replication/repair;
Short life span;
Cannot, divide/replace themselves. **[2]**

Q19.

5 **(a)** **(i)** 700 000/5 400 000 x 100; AW e.g. 6,100,000/5,400,000 = 112.96% – 100 (= 12.96%)

13; **R** 12.96
1 mark for working, 1 mark for correct answer **[2]**

(ii) (more red cells =) more haemoglobin;
more oxygen can be carried (per unit volume of blood);
at altitude the partial pressure of oxygen is, low/lower than at sea level;
A less oxygen at altitude **R** ref to lower Hb saturation
more red cells/more haemoglobin, compensates for lower saturation, of haemoglobin; **A** affinity **[max 2]**

Q20.

6 **(a)** **(i)** **F** vena cava;
G pulmonary artery; **[2]**

(ii) 75; **R** inappropriate units e.g.dm^3/min **[1]**

(iii) ventricles pump blood, to lungs/to whole body/further;
atria pump blood, to ventricles/shorter distance;
correct reference to pressure; e.g. ventricles have to push blood further so blood under higher press or create higher press
R atria at lower press or ventricles receive blood at higher press **[max 2]**

(b)

	left atrium	left ventricle	atrio-ventricular valve	aortic valve
H	*contracts to force blood into left ventricle*	Diastole/relaxes, filling with blood/receives blood, from left atrium;	*open*	*closed*
J	Diastole/relaxes, fills with blood/receives blood, from pulmonary veins;	Systole/contracts, forcing blood into aorta;	*closed*	open
K	Diastole/relaxes, fills with blood/receives blood, from pulmonary veins;	*relaxes and fills with blood from left atrium*	*open*	closed;

[6]

[Total: 11]

Q21.

2 (a) (i) haem / prosthetic group ; **A** porphyrin

site of attachment of / binds with / carries / combines with / joins with / takes up / transports, oxygen ;
R absorbs / reacts with / stores
(oxygen binds to) iron ion / Fe^{2+} / FeII (in haem) ;
A atom, of iron / ferum [3]

(ii) *tertiary*
(each) polypeptide / protein, with complex 3D shape ;
folding of secondary structure / folded alpha helices ;
polypeptide / protein, coiled / folded / curled up / compact ;
1 max

quaternary
more than one polypeptide / AW ; [2]

(b) (i) 58 ;
100 ; [2]

(ii) partial pressure of oxygen in tissues is low ; **A** concentration
percentage saturation decreases sharply ;
A appropriate ref to 'steepest part of the curve'
small decrease in partial pressure of oxygen / 6 to 2 kPa, causes very large change in % saturation with oxygen ;
78–80 to 22–24% saturated ; **A** appropriate figure(s)
this = range of partial pressures of oxygen in (respiring) tissues ;
(oxy)haemoglobin, dissociates / 'gives up its oxygen', at low partial pressures of oxygen ;
ref to, distortion of haemoglobin molecule and ability to release oxygen / allosteric effect / cooperative binding ; [4 max]

(c) *accept curve drawn on Fig. 2.3*
same shape as existing curve – begins at origin, ends at 95%–100% ;
to the **right** of existing curve ; [2]

[Total: 13]

Q22.

4 (a) sino-atrial node / sinu-atrial node / sinoatrial node / SAN ; [1]

(b) myogenic, explained (e.g. contracts and relaxes without stimulation) ;
SAN / pacemaker, sends out, waves of excitation / impulses ;
spreads across atria (and causes atria to contract) ;
fibrous ring / non-conducting tissue / insulating tissue, prevents it reaching the ventricles ;
time delay to allow, atria to empty / ventricles to fill *or* time ref. (0.1–0.2 seconds) ;
atrio-ventricular node / AVN, acts as 'relay station' ;
relays impulse to Purkyne tissue / bundle of His ;
Purkyne tissue conducts impulse to, base / apex of heart / septum / ventricles; [4 max]

(c) 60 / 0.8 ;
75 ; [2]

(d) lower / less, resistance (within pulmonary tissue) ; *ora*
lower / less force needed ; *ora*
short distance / only has to pump blood to lungs ; *ora* ;
because RV wall is, thinner / less muscular ; *ora* [2 max]

[Total: 9]

Q23.

4 **(a)** blood passes through the heart twice during one (complete) circuit of the body ;
A one cycle / one circulation **R** cardiac cycle
A systemic / body, and, pulmonary / lung, circulation [1]

(b) withstands high(er) blood pressure ;
maintains blood pressure ;
ref to more, elastin / collagen / (smooth) muscle ;
A thicker muscle [2 max]

(c) vasoconstriction / contract / constrict / close / narrow, to, stop / control / reduce, blood flowing through capillaries ;
blood, diverted / shunted, elsewhere ;
any suitable e.g. ; diverted from, skin when cold / gut during exercise

vasodilation / relax / dilate / open / widen, to allow blood to flow through capillaries ;
blood required in tissue to deliver, oxygen / glucose *or* to remove, lactate / carbon dioxide ;
[1 max]

(d) pores / gaps / perforations, in / between, (endothelial) cells ;
A pores in capillary wall **R** spaces, holes
water / ions / glucose, move out ; **A** named small soluble substances
***R** list which contains incorrect substance* / red blood cells
hydrostatic pressure of blood is greater than (hydrostatic) pressure of tissue fluid ;
(causing) pressure filtration / AW e.g. forced out under pressure / ultrafiltration ; **R** leaking
pinocytosis across capillary wall ; [3 max]

(i) *any three of the following*
more / plasma, proteins ;
more glucose ; **R** sugars
more, fat / fatty acids / glycerol ;
lower, water / solute, potential ; **R** water concentration
lower carbon dioxide concentration / lower concentration of HCO_3^- ;
higher oxygen concentration ;
AVP ; e.g. cell secretes substance that is in higher concentration in tissue fluid, another named solute, higher pressure [3 max]

(ii) lymph / lymphatic fluid ; [1]

[Total: 11]

Q24.

(c) reduced supply of blood to, heart / cardiac, muscle ;
reduced supply of glucose (to cardiac muscle) ; **R** no
reduced supply of oxygen (to cardiac muscle) ; **R** no
less aerobic respiration / (more) anaerobic respiration (of cardiac muscle) ;
build up of, lactate / carbon dioxide ;
ref. limited cardiac output ;
AVP ; e.g. ref. to consequences to (muscles of) body with reduced blood supply, ref. to pain caused by angina **R** heart attack / AW [3]

(d) damages, lining of arteries / endothelium ; *accept once*
speeds up (atheromatous / fibrous) plaque development ; *accept once*
increases chance of blood clotting / promotes thrombosis ; *accept once*

nicotine
increases heart rate / AW ;
increases blood pressure ;
makes platelets 'sticky' ;
decreases blood flow to, extremities / AW ;
constriction of blood vessels ; (max 2)

carbon monoxide
combines with haemoglobin / forms carboxyhaemoglobin / higher affinity for haemoglobin (than oxygen) ;
reduces oxygen-carrying capacity / AW (in context of, haemoglobin / blood) ;
promotes release of damaging free radicals / peroxides / superoxides / oxidising agents ;
causes, platelets and neutrophils to stick together / platelets to stick to endothelium ;
ref. hypoxia damage to cardiovascular system ; (max 2) [max 3]

Q25.

(c) 4, oxygen molecules / O_2, per (molecule of) haemoglobin ;
(forms) oxyhaemoglobin (in lungs) ; **A** marking points 1 and 2 as equation
ref. oxygen remains bound until blood in area of low pO_2 / high pCO_2 / high(er) temperature ; **A** in area of respiring tissues (max 3)
carbon dioxide combines with haemoglobin ;
terminal, amine / amino, group of haemoglobin ; **A** $-NH_2$
carbamino-haemoglobin ; **R** carboxyhaemoglobin
ref. to hydrogen ions from carbonic acid ;
ref. carbon dioxide remains bound until blood in area of low pCO_2 / high pO_2 ; [max 4]

(d) **(i)** 19.7 / 20 (%) ;;

allow 1 mark if incorrect answer but correct working shown
7.3 – 6.1 / 6.1 × 100 / 1.2 / 6.1 × 100 [2]

(ii) partial pressure / AW, of oxygen is, low / lower than at sea level ;
haemoglobin less well saturated ;
more red blood cells / more haemoglobin ;
compensates for, smaller volume of oxygen absorbed (per red blood cell) / lower saturation of haemoglobin ;
A ref. to tissues receiving sufficient oxygen
AVP ; e.g. ref to erythropoietin (EPO) [max 3]

Q26.

2 (a) (i) acts as a pacemaker / regulates heartbeat ;
A ref. to myogenic / described e.g. as rythmn / AW

releases / AW, waves of excitation / depolarisation / (electrical) impulses / action potentials ;

R nerve impulses / signals / messages / waves unqualified

atrial systole / atrial contraction(s) ; **A** initiates, heart beat / cardiac cycle
ref. to nervous innervation allowing changes ; [max 2]

(ii) delays, impulse / AW ;
R nerve impulses / signals / messages / waves unqualified
A *ecf* from **(i)**

sends impulse to, Purkyne fibres / Bundle of His / ventricles / septum ;

allows atrial systole to complete before ventricular, systole / contraction(s) ;
A *idea that* allows ventricles to fill (before they contract)
A *idea that* allows atria to, empty completely / complete contraction [max 2]

(iii) *either*
stops backflow (of blood) ;
(stops backflow) from ventricle to atrium ; **R** if ref. to right

or
allows one-way flow of blood ;
allows flow from atrium to ventricle ; **R** if ref. to right [max 2]

(b) C ;
G ;
G ;
B / C ; [4]

[Total: 10]

Q27.

5 (a) *closed* blood travels, inside blood vessels / AW ;
double blood travels through the heart twice during one, complete circuit / circulation of the body ; AW
A pulmonary and systemic, systems / circuits [2]

(b) **P** to right atrium ;
Q to (semilunar) pulmonary or aortic valve ;
R to, vena cava / pulmonary artery ;
S to, septum / wall(s) of ventricles ; [4]

(c) (i) 75 (beats per minute) ;;

if incorrect answer or no answer allow one mark for extraction from Fig. 5.2 or for correct working
e.g.10 beats in 8 seconds
10/8 × 60 [2]

(ii) *max 3 if only description or only explanation given*
lowest pressure in aorta, is 10.8 kPa / varies between 10.8-11.2 kPa v in left ventricle is 0 KPa ;
difference between highest and lowest is greater in the ventricle / AW ;
4.8 – 5.2 kPa for aorta, 16.0 kPa in left ventricle ;

reference pressure differences (in left ventricle) as a direct result of ventricular systole and diastole ;
semilunar / aortic, valve prevents backflow from aorta into ventricle ;
(so) no / little, blood in ventricle, when fully contracted / AW ;
elastic recoil of artery maintains (diastolic) blood pressure ;
AVP ; [max 4]

(d) **(i)** coronary arteries ; [1]

(ii) insufficient, glucose / oxygen (to, cardiac / heart, muscle) ;
angina ;
heart attack / myocardial infarction / cardiac arrest ;
description of anaerobic conditions in muscle ; [max 1]

(e) coronary (artery) by-pass (graft) operation ;
R by-pass *unless qualified*
A described
insertion of a (coronary) stent ; **A** described
heart transplant ;
angioplasty ; **A** described
AVP ; e.g. calcium-channel blockers / named
further detail of treatments e.g. anticoagulants after angioplasty [max 2]

[Total: 16]

Q28.

6 **(a)** *one mark each correct label to max 3;;;* [max 3]

(b) **X** marked over coronary artery section before graft joins; [1]

(c) cure for, coronary artery disease / atherosclerosis in artery;
A arteriosclerosis
so less risk of, myocardial infarction / heart attack / AW;

prevention of coronary artery disease to avoid bypass surgery
one example; e.g. no smoking
increase exercise
low, (saturated) fat / cholesterol, diet
reduce alcohol consumption
reduce salt intake
statins
avoid, excessive / AW, sugar
avoid obesity

ref. to difficulties in getting people to change lifestyle to prevent;

disadvantage of, surgical procedure / cure;
accept ora prevention
e.g. invasive / painful
costly medical
lost time / money, by absence from work
risk of complications / graft rejection / infection
risk / graft becoming diseased / collapsing

AVP; e.g. *idea that* as cure is available, more difficult to encourage prevention [max 3]

[Total: 7]

Q29.

1 **(a)** 1.4 mm ; ;
two marks for the correct answer
A 1.3 / 1.34 / 1.37 / 1.43 / 1.46 / 1.5

tolerance on measurement of 49 mm = ± 2 mm (i.e. 47 to 51 mm)

*if answer not given or incorrect allow one mark for correct measurement and correct use of formula (measurement divided by the magnification of 35 **or** showing the rearranged formula)* [2]

(b) 1 large / wide, lumen (relative to thickness of wall) ;
A artery narrow lumen

2 irregular shape ; AW
A flattened / oval / not round(ed) (shape) ;
A artery, round(ed) / regular (shape)
I ref. to (vein) not spherical / artery spherical

3 thin / AW, tunica media / middle layer / (smooth) muscle and elastic layer
or
(proportionately) less, elastic / (smooth) muscle, in, tunica media / middle layer ;

4 (relatively) thin, tunica externa / tunica adventicia / outer layer / fibrous coat / fibrous layer ;
R small(er)

5 tunica intima / tunica interna / inner layer / endothelium, smooth / not 'crinkly' / not wavy / AW ;

alt *if mp 3 not awarded, award 1 mark only for*
thin (smooth) muscle layer / less (smooth) muscle
thin elastic layer / less elastic tissue } [max 3]

(c) **(i)** short distance for diffusion (of molecules / ions / named) ;
A reduced distance / thin / short pathway / AW

increased rate / AW, of diffusion (of molecules / ions / named) ;
A fast(er) / (more) efficient
I easy / better [max 1]

(ii) 1 small size allows contact with (many body) cells / AW ;
A *idea of* extending into small spaces

2 red blood cell, close to, (body) cells / tissue for (efficient), diffusion / AW ;
A in contact with / close to, capillary wall / endothelium, for diffusion

3 red blood cells / blood flow, slow(s) down / *idea of* more time,
for (efficient) diffusion / cells to obtain sufficient nutrients / AW ;
treat ref. to lower pressure as neutral

4 (plasma / blood, containing), glucose / nutrients / named nutrient / oxygen,
close to / AW, body cells ; [max 1]

Q30.

4 **(a)** **W** right atrium labelled in lumen / wall ;
X tricuspid valve labelled ; **A** valve flap / chordae tendinae *see encircled area on diagram*
Y aorta labelled ; [3]

(b) *needs to be a sequence, not events in the cardiac cycle e.g.* ***I*** *valves*

aorta, body (tissues / blood vessels) / capillaries / systemic circulation, vena cava ;
A body cells
right atrium and right ventricle ;
pulmonary artery (to lungs) ; **R** if blood comes from left ventricle [3]

(c) *max 2 for structural features*
I *fast diffusion, efficient diffusion, reduces diffusion distance*
mps 4, 6, 8 and 10 – can be awarded if related structure is not given but is implied

1 many alveoli ;
2 large surface area ; **I** high SA:V ratio / increase SA
3 many capillaries / network of capillaries ; **I** good blood supply
4 (so) maintain, diffusion / concentration / partial pressure, gradient(s) ;
5 lining / epithelium / wall, of, alveoli / gas exchange surface, is thin / one cell thick / squamous ; **I** thin interstitium
R 'cell walls of' **R** lungs **R** alveoli are one cell thick **R** endothelium / membrane
6 (so) short diffusion distance / only diffuse through two cells ;
7 ref. to, elastin / elastic fibres ; **I** alveoli are elastic
8 (so) allows alveoli to, increase in volume / expand / stretch / stop bursting / recoil ;
R contract
9 (alveolar type II cells secrete) surfactant ;
10 (so) reduces surface tension ; [max 4]

[Total: 10]

Q31.

(b) **1** increases heart rate ;
A heart, pumps / beats faster

2 increased blood pressure / hypertension ;

3 damage to, endothelial / arterial, lining ;
A damage to, tunica intima / lining of veins

4 (so) contributes to plaque / atheroma ;
A atherosclerosis

5 vasoconstriction
or
constricts / reduces diameter of, arterioles / blood vessels ;
A more resistance to blood flow *must be in context*

6 reduced blood flow to extremities / AW ; [max 3]