2224 – 6009M

Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2024

Biology

Higher level

Paper 3

33 pages

Subject Details: Biology HL Paper 3 Markscheme

Candidates are required to answer **all** questions in Section A and **all** of the questions from **one** option in Section B. Maximum total = **45 marks**.

1. Each row in the "Question" column relates to the smallest subpart of the question.

2. The maximum mark for each question subpart is indicated in the "Total" column.

3. Each marking point in the "Answers" column is shown by means of a semi-colon (;) at the end of the marking point.

4. A question subpart may have more marking points than the total allows. This will be indicated by "**max**" written after the mark in the "Total" column. The related rubric, if necessary, will be outlined in the "Notes" column.

5. An alternative word is indicated in the "Answers" column by a slash (*/*). Either word can be accepted.

6. An alternative answer is indicated in the "Answers" column by "***OR***". Either answer can be accepted.

7. An alternative markscheme is indicated in the "Answers" column under heading ***ALTERNATIVE 1*** *etc*. Either alternative can be accepted.

8. Words inside brackets ( ) in the "Answers" column are not necessary to gain the mark.

9. Words that are <u>underlined</u> are essential for the mark.

10. The order of marking points does not have to be as in the "Answers" column, unless stated otherwise in the "Notes" column.

11. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the "Answers" column then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by ***OWTTE***.

12. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

13. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking, indicate this by adding **ECF** (error carried forward) on the script.

14. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the "Notes" column.

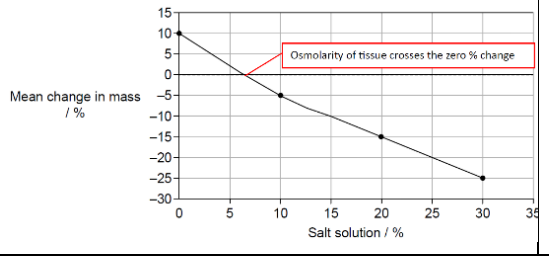
Section A

Question			Answers	Notes	Total
1.	**a**	**i**	a. count all cells in any stage of mitosis; b. divide by total number of cells; c. convert to percentage ***OR*** multiply by 100;	*Do not accept other terms than cells.*	**2 max**
1.	**a**	**ii**	0.015mm or 15 µm;	*Units required, working not required.* *Accept answers between 14 and 16 µm.* *Accept any other correct format, e.g. 15 x 10^{-6} m.*	**1**
1.	**b**	**i**	as concentration increases mitotic index decreases ***OR*** negative effect/correlation/relationship;		**1**
1.	**b**	**ii**	decreased growth/cell proliferation;		**1**

Question			Answers	Notes	Total
2.	**a**		measure of solute concentration / total number of solute/salt particles per litre;	*Do not accept sugar.*	**1**
2.	**b**		a. higher luminescence at higher (external) osmolarities; b. (at all osmolarities) relative luminescence increases with bacterial density between 0 to 1 arbitrary units; c. (at the two highest osmolarities) relative luminescence remains relatively stable with bacterial density from 1 to 5 (arbitrary units); d. at low osmolarity, relative luminescence decreases after 1 (arbitrary unit); e. lack of error bars does not allow for valid comparisons;		**2 max**

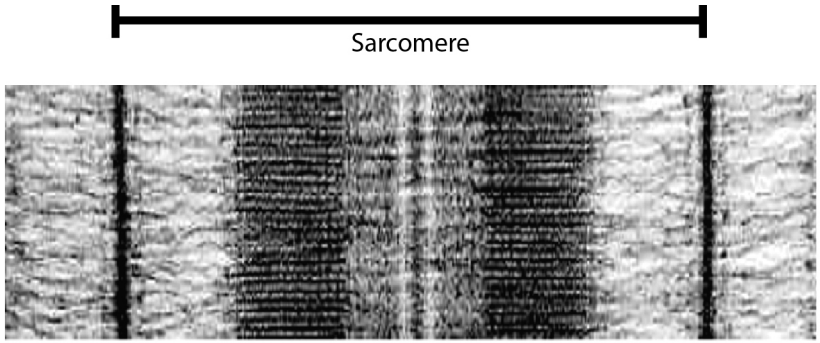
Continued…

Question 2 continued

Question			Answers	Notes	Total
2.	**c**		a. (percentage) change in mass can be used; b. plot concentration of solution on *x*-axis ***AND*** (percentage) change in mass on *y*-axis ***OR*** gain in mass means hypotonic (solution)/vice versa; c. point where data line intercepts zero (%) change in mass is osmolarity/osmotic concentration (of tissue) ***OR*** no change in mass means isotonic (solution);	*Answer must refer to mass of (cylinders/tissue).* *a. Accept increase/decrease.* *b. Both axes needed for **[1]*** *Accept sketch of graph correctly drawn and annotated e.g.*  	**2 max**

Question			Answers	Notes	Total
3.	**a**	**i**	sex/gender/age/physical condition**;**	*Mark only the first answer written.* *Accept other valid answers.* *Hand size, occupation, sports played could all be considered under "physical condition".*	**1**
3.	**a**	**ii**	a. muscle <u>fatigue</u> ***OR*** cannot sustain contraction for extended period of time; b. depletion/decrease (in production) of ATP/Ca^{++} ions in (hand/arm) muscle cells;		**1 max**

Question 3 continued

Question			Answers	Notes	Total
3.	**b**	**i**	labelled correctly;  [Source: Bergtrom, Gerald, "Annotated Cell and Molecular Biology 5e: What We Know and How We Found Out" (2022). *Cell and Molecular Biology 5e: What We Know and How We Found Out - All Versions*. 15. https://dc.uwm.edu/biosci_facbooks_bergtrom/15. Licensed under CC BY 4.0 Deed (https://creativecommons.org/licenses/by/4.0/deed.en)]		**1**
3.	**b**	**ii**	a. muscle contracted; b. contraction achieved by sliding of actin ***AND*** myosin filaments/OWTTE; c. light/I band is smaller/narrower/shorter ***OR*** Z lines closer together in II ***OR*** sarcomere is shorter in II / vice versa;	*b. Both needed; accept myosin pulls on actin.* *Details of mechanism not required since the command term isn't «explain».*	**2 max**

Section B

Option A — Neurobiology and behaviour

Question			Answers	Notes	Total
4.	**a**		*Similarities [max 1]* a. all bat species showed social grooming; b. all species have no grooming periods; *Differences [max 1]* c. social grooming higher in vampire bats/*D. rotundus* than all non-vampire bats; d. *A. jamaicensis* showed higher grooming rate than other non-vampire bats ***OR*** *R. aegyptiacus* showed lower grooming rate than other non-vampire bats;		**2 max**
4.	**b**		a. more social grooming among vampire bats as helps maintain social bonds; b. aids for population survival; c. needed for reciprocal food sharing/builds cooperative relationships; d. less social grooming among non-vampire bats as do not show altruistic feeding; e. grooming necessary to remove (ecto)parasites;		**3 max**

Question			Answers	Notes	Total
5.	**a**		a. (harmless) dye injected to make blood flow visible; b. subject performs a task/responds to stimuli (while in scanner and images taken); c. active parts of brain receive increased blood flow; d. oxygenated blood is detected;		**2 max**
5.	**b**		*Similarities [max 1]* a. none have activity in the right hemisphere; b. control and survivors with best motor function show activation in similar areas of two regions; *Differences [max 1]* c. stroke survivors with worst motor function shows no activation in either area; d. stroke survivors (with best function) show activation in larger area/volume than control ***OR*** stroke survivors (with best function) uses more of motor area than control;		**2 max**
5.	**c**		a. (neural) plasticity; b. formation of new synapses; c. reorganization of brain function ***OR*** other areas of brain take over the function of damaged areas/OWTTE;	*c. Accept neurons migrate and take over function.*	**2 max**

Continued…

Question 5 continued

Question			Answers	Notes	Total
5.	**d**		*Name*: cerebellum; *Function*: coordinate unconscious/involuntary (motor) functions/posture/balance/movement;		**2**

Question			Answers	Notes	Total
6.	**a**	**i**	a. X: (rod cell) high sensitivity to light/respond to low light intensity; b. Y: (ganglion cell) sends/transmits impulses/messages to brain via optic nerve; c. Z: (bipolar cell) sends/transmits impulses/messages from rods/cones to ganglion cells;		**3**

Continued…

Question 6 continued.

Question			Answers	Notes	Total
6.	**a**	**ii**	arrow drawn from left to right;	*Accept arrow in the correct direction in any position of any size.*	**1**
6.	**b**		a. red cannot be distinguished from green; b. lack/deficiency in red/green cones/pigments; c. due to (recessive) sex-linked gene;	*b. Do not accept receptors.*	**2 max**

<table>
<tr><th colspan="3">Question</th><th>Answers</th><th>Notes</th><th>Total</th></tr>
<tr><td>7.</td><td>a</td><td></td><td>
<table>
<tr><th></th><th>Innate</th><th>Learned</th></tr>
<tr><td>a.</td><td>genetically determined</td><td>not inherited;</td></tr>
<tr><td>b.</td><td>independent of environment/same for all members of species</td><td>depends on environment/experiences;</td></tr>
</table>
</td><td>Award a mark for each correct row: distinctions should correspond.
Table not required but need valid comparison.</td><td>2</td></tr>
<tr><td>7.</td><td>b</td><td></td><td>a. conditioned learning involves types of associative learning where a stimulus becomes associated with a consequence;

Reflex/classical conditioning: [max 2]
b. an automatic/unconscious/involuntary response is paired with specific stimuli;
c. example of reflex conditioning/reference to Pavlov’s experiments with dogs;

Operant conditioning: [max 2]
d. learning through trial and error/experience;
e. association between a voluntary/conscious stimulus and a consequence;
f. strengthen or weaken a behavior by giving a reward or a punishment
OR
a specific example of operant conditioning e.g., training dogs with a treat for correct behaviour;</td><td>e. Do not accept reflex.</td><td>3 max</td></tr>
</table>

Question			Answers	Notes	Total
8.			*Release and reception [max 2]* a. neurons send signals to other neurons via synapses using neurotransmitters; b. neurotransmitters are (chemicals messengers) released by exocytosis/vesicles (in the presynaptic neuron); c. neurotransmitters bind to receptors on the postsynaptic neuron; d. neurotransmitters excite or inhibit action potential (in postsynaptic neuron); *Drugs [max 5]* e. (many) drugs/chemicals mimic structure of neurotransmitters ***OR*** (many) drugs/chemicals bind to specific receptors; f. psychoactive/stimulant drugs can increase/decrease/prevent postsynaptic transmission; g. inhibitory drugs block/decrease synaptic transmission; h. some drugs bind to the presynaptic membrane and affect the release of neurotransmitters; i. example: MDMA/ecstasy blocks presynaptic membrane reuptake of dopamine/increases release of dopamine in synapse; j. some drugs bind to postsynaptic membrane and affect uptake of neurotransmitters; k. example: nicotine/cocaine binds to postsynaptic membrane and causes depolarization/activation ***OR*** cocaine binds to presynaptic membrane and blocks dopamine reuptake;		**6 max**

Option B — Biotechnology and bioinformatics

Question			Answers	Notes	Total
9.	**a**		a. renewable energy source/reduce dependency on fossil fuels; b. reduced greenhouse gas emissions; c. waste reduction; d. biogas is flexible end-use/can be used for many diverse processes/home cooking to electricity generation;	*b. Do not accept "cleaner fuel".*	**1 max**
9.	**b**	**i**	*Similarities [max 1]* a. production increases with time for all combinations; b. show the same trend / OWTTE; c. all have stationary phase in beginning/until day 7/8 ***OR*** for all some production at day 2 ***OR*** all show (large) increase from day 7/8; *Differences [max 1]* d. gas production by cow dung only is (usually) highest; e. gas production by cow dung with fruit and vegetable waste always lowest;		**2 max**
9.	**b**	**ii**	batch because gas was not harvested until the end ***OR*** nutrients added at start/not continually added;	*Do not award a mark if a reason is not provided.*	**1**

Continued…

Question 9 continued

Question			Answers	Notes	Total
9.	**c**		a. uses knowledge of metabolic pathways; b. uses genetic engineering to optimise regulatory conditions (in microorganisms); c. to change conditions/add extra substrates/remove byproducts that slow rate of reaction;		**2 max**

Question			Answers	Notes	Total
10.	**a**		active/free-living cells;		**1**
10.	**b**		a. cells in (exo) polysaccharide matrix/exopolymeric/EPS matrix protected; b. (EPS) does not let phage pass/bind to receptors on bacteria; c. dispersed biofilms increase the surface area and thus susceptibility; d. reduced metabolic activity/growth rate of bacteria in biofilm does not allow phages to multiply; e. increased cell density limits effect of phage; f. quorum sensing induces defense against bacteriophages/emergent properties;		**3 max**

Question			Answers	Notes	Total
11.	**a**		a. name of pollutant released ***AND*** location; b. source of pollutant; c. name the organism used in bioremediation; d. name product formed by microorganism/what microorganism uses pollutant for;	*All elements must refer to the same example.* *Accept any verified example.* *a. Both needed.*	**3 max**

Question			Answers	Notes	Total
12.	**a**		a. influenza virus has RNA as genetic material; b. (RNA) needs to be converted to cDNA to use with PCR; c. DNA contamination would be amplified when using normal PCR;		**2 max**
12.	**b**		fluorescent dye;	*Accept verified name for the dye.* *Accept UV light/radioactive markers.*	**1**
12.	**c**		a. lane 4 has subtype H1 while lane 3 has subtype H3; b. lane 4 has subtype N1 while lane 3 has subtype N2; c. lane 4 is (subtype) H1N1; d. lane 3 is (subtype) H3N2;		**2 max**

Question			Answers	Notes	Total
13.	a		a. three copies of chromosome 21 results in Down Syndrome; b. Ensembl/database provides information about genes on the chromosome; c. can compare genes on human chromosome 21 with similar genes in other species; d. investigate functions of genes; e. may lead to therapies for Down Syndrome;		**3 max**
13.	b		a. short (sub-) section of cDNA made from expressed mRNA; b. does not contain introns ***OR*** contains only coding regions; c. are portions of genes that usually are conserved/don't change across species; d. used for gene discovery ***OR*** identify mutated genes/genetic disorders; e. used to find location of gene on chromosome; f. used for phylogenetic studies/develop cladograms;		**3 max**

Question			Answers	Notes	Total
14.			*Benefits: [max 3]* a. increased crop yields ***OR*** reduced demand for more land; b. less application of other herbicides to control weeds ***OR*** glyphosate can replace more persistent herbicides; c. less need for plowing resulting in less soil erosion; d. less plowing/herbicide application uses less fuel/less emissions produced; *Risks: [max 3]* e. increased growth/differential survival of resistant (weed) population ***OR*** natural selection for herbicide/glyphosate resistance (in weeds); f. evolution of resistance is possible due to pre-existing variability; g. (strong) selective pressure by presence of herbicide/glyphosate; h. gene spreads to other plant species; i. possible allergic reactions of consumers;		**6 max**

Option C — Ecology and conservation

Question			Answers	Notes	Total
15.	**a**	**i**	distribution of Corsican pine;		**1**
15.	**a**	**ii**	major habitat (of nuthatch) ***OR*** other factors affecting the importance of Corsican Pine for the nuthatch;	*If 15 a i is incorrect, award mark for a valid reason and apply ECF.* *Other factors may include breeding site, feeding site, protection from predators, camouflage, etc.*	**1**
15.	**b**		a. niche is the ecological role a species fulfils ***OR*** niche includes how species obtains food and interactions with other species/suitable abiotic factors in an ecosystem; b. fundamental niche is potential mode of existence of species/potential niche occupied ***OR*** fundamental refers to broadest range of habitats it can occupy and roles it can have; c. realized niche is portion of fundamental niche that the species actually occupies in a particular environment/actual niche occupied;		**2 max**

Continued…

Question 15 continued

Question			Answers	Notes	Total
15.	**c**		a. (because the Corsican pine forests are declining there is a) loss of habitat/food source/nesting sites/protection from predators; b. not able to adapt to other habitats;	*Accept other factor related to decline of Corsican pine forest.* *Accept examples such as e.g., deforestation, human activity, etc.* *Do not accept 'global warming'.*	**1 max**

Continued…

Question 15 continued

Question			Answers	Notes	Total
15.	**d**		*Island size* a. larger area/island size has more species/habitats/niches/resources ***OR*** more species means greater biodiversity ***OR*** larger area/island size means greater biodiversity; b. larger areas have more stability to maintain biodiversity ***OR*** larger areas are less affected by environmental events; *Edge effect [max 2]* c. (generally) larger island size has a smaller edge effect; d. more limiting factors decrease biodiversity ***OR*** edges with extreme abiotic factors decrease biodiversity; e. overlapping ecosystems/edges increase biodiversity; f. overlap results in more abiotic factors/conditions;	*a. Do not accept "populations" instead of "species".* *Accept vice-versa.*	**3 max**

Question			Answers	Notes	Total
16.	**a**		a. biological control; b. to feed on cane/scarab beetles in cane fields; c. did not work as a (biological) control/OWTTE; d. lack of predators ***OR*** became invasive; e. negative effect on native species/rapid spread;	*b. Do not accept pests.* *c. Could not reach the beetles.*	**2 max**
16.	**b**		a. cane toads hatch over wider pH range/pH 4 to 10; b. at lower pH/more acidity, hatching increases (significantly) but low pH has less body growth (over 8 weeks)/ OWTTE ***OR*** more acidic water bodies may have more cane toads but of smaller size; c. more may survive in acidic water ***OR*** smaller toads may be prey to predators/have a lower survival rate; d. toads in water with pH 10 (appear to) die at week 4 limiting distribution; e. investigation in lab may yield different results than natural habitat ***OR*** percentage hatching/body length doesn't equate percentage of survival ***OR*** no information on sample size/error bars; f. distribution limited to pH 4 to 8.5 (as tadpoles die at pH of 10);	*Accept vice versa.* *2 Max if only mention one dependent variable: hatching or body length.* *Accept correct answers dealing with separate effect on hatching and body length.*	**3 max**

Question			Answers	Notes	Total
17.	a		an indicator species is an organism used to assess a specific environmental condition ***OR*** survive within a limited range of environmental conditions thus presence/absence shows condition of an ecosystem/OWTTE;		**1**
17.	b		a. used to obtain environmental assessment of an ecosystem; b. large population of indicator species determines health of environment; c. high biotic index indicates healthy environment/vice-versa ***OR*** high biotic index suggests high number of pollution sensitive organisms; d. used to monitor over time ***OR*** used as an early warning system;	*Do not award marks for simply stating the formula.*	**3 max**
17.	c		a. remains in the environment/not biodegradable; b. (taken in by organisms and) stored in fat tissues/bioaccumulates/not excreted; c. biomagnification / concentration increases up the food chains; d. may cause cancer/liver damage/infertility/weaken birds' eggshells/kills insects/other verified effect;		**2 max**

Question			Answers	Notes	Total
18.	**a**		a. used only for sessile organisms; b. transect laid in straight line/along environmental gradient; c. quadrats placed along transect line at intervals; d. used to determine abundance/distribution of organisms/diversity index;	*c. Do not accept quadrats placed at random without reference to a transect.* *d. Accept reference to Chi square to determine distribution.*	**2 max**
18.	**b**		vascular plants;		**1**
18.	**c**		a. primary succession; b. no original organisms; c. pioneer plants come first/brought by wind/birds; d. create soil/humus; e. allows other plants to then take hold;	*b. Accept plants.*	**2 max**

Question			Answers	Notes	Total
19.			a. (industrial) agricultural practices require a large quantity of phosphate; b. phosphate removed by harvesting of agricultural crops; *Benefits:* c. phosphorus added to phosphorus cycle by application of fertilizer; d. (application of phosphate) increases crop yield; *Risks:* e. availability of phosphate decreasing; f. lack of phosphate may become limiting factor to agriculture in the future; g. turnover (rate) in phosphorus cycle is very low/not readily replenished ***OR*** consumption faster than production; h. leaching of nutrients/phosphates from agricultural land into bodies of water; i. (leaching) causes eutrophication ***OR*** (leaching) leads to increased biochemical oxygen demand in bodies of water;	*Accept rivers, lakes, ponds, etc.*	**6 max**

Option D — Human physiology

Question			Answers	Notes	Total
20.	**a**		dehydration/diarrhea/vomiting;	*Mark only the first answer written*	**1**
20.	**b**		a. young people more likely to be in a situation where they contract cholera/bacteria/OWTTE; b. more young people in population/OWTTE; c. older people less likely to go to hospital; d. older people with more resistance/immunity to cholera/bacterium; e. other valid reason;	*Accept vice versa*	**1 max**
20.	**c**		a. water/salt absorbed; b. materials not absorbed are egested/eliminated ***OR*** formation of feces; c. peristalsis occurs ***OR*** fiber aids transit through the large intestine;	*b. Do not accept excreted.*	**2 max**

Question			Answers	Total	Notes
21.	**a**		*Similarities [max 1]* a. both (poor and good sleepers) show increase in heart rate during exercise ***AND*** decrease during recovery **OR** both show the same trend throughout; b. both have similar/highest heart rate at peak exercise; *Differences [max 1]* c. poor sleepers always had a higher heart rate than good sleepers / vice versa; d. between stage 3 and peak exercise, the good sleepers have greater increase in mean heart rate;		**2 max**
21.	**b**		a. atrioventricular valves close (first) (lub); b. semilunar valves close (second) (dub);		**2**
21.	**c**		a. risk factor in CHD/heart attack/stroke/diabetes type II; b. damages lining/walls of arteries ***OR*** rupture of blood vessels; c. promotes plaque production/atherosclerosis;	*a. Do not accept high blood pressure.*	**2 max**

Question			Answers	Notes	Total
22.	**a**		a. <u>autosomal recessive</u> genetic/inherited disorder; b. lack of the enzyme (in liver) <u>phenylalanine hydroxylase;</u> c. error of amino acid metabolism **OR** build-up of phenylalanine/phenyl ketone (in the blood);		**2 max**
22.	**b**		*Strengths [Max 1]* a. phenylalanine levels go down 8 / 15 hours after THB given; b. after 15 hours significantly lower than original level of phenylalanine (before meal); *Limitations [Max 1]* c. at 4 hours (after meal) phenylalanine levels (in the blood) do not decrease ***OR*** takes 8 to 15 hours to reduce the phenylalanine levels (in the blood)/slow acting; d. doesn't consider the normal decrease of phenylalanine (in the blood)/OWTTE ***OR*** results of this study cannot be generalized ***OR*** different types of PKU may not respond ***OR*** no control ***OR*** not enough information/data/OWTTE;		**2 max**

Continued…

Question 22 continued.

Question			Answers	Notes	Total
22.	**c**		a. traditional treatment requires protein restricted diet (for life); b. ability to eat normal diet (containing protein/phenylalanine); c. use of less protein supplements without phenylalanine;		**2 max**

Question			Answers	Notes	Total
23.	**a**		<table><tr><th></th><th>Steroid</th><th>Peptide</th></tr><tr><td>a.</td><td>binds to receptor in cytoplasm (of target cell)</td><td>binds to receptor in <u>plasma membrane</u> (of target cell);</td></tr><tr><td>b</td><td>hydrophobic/lipophilic/non-polar</td><td>hydrophilic/lipophobic/polar;</td></tr><tr><td>c.</td><td>receptor-hormone complex formed</td><td>causes release of second messenger/cAMP inside cell;</td></tr><tr><td>d.</td><td>complex promotes transcription of specific genes</td><td>cascade results in enzyme activity altered/increased/decreased ***OR*** causes activation of protein kinase;</td></tr></table>	*Table not required.* *Differences between each required to award each mark.*	**2 max**

Continued…

Question 23 continued

Question			Answers	Notes	Total
23.	**b**		a. gastrin secreted by walls of stomach when food enters stomach; b. stimulates (further) secretion of acid/HCl by parietal cells; c. (also) pepsinogen by chief cells; d. secretin/somatostatin inhibits gastrin secretion; e. (secretin released) if pH in stomach falls too low ***OR*** fats enter duodenum;		**3 max**
23.	**c**		*Prolactin*: a. produced by the <u>anterior</u> pituitary; b. stimulates mammary glands to grow ***OR*** stimulates the production of milk; *Oxytocin*: c. produced in neurosecretory cells (in hypothalamus) ***OR*** stored/secreted by <u>posterior</u> pituitary; d. suckling/nursing stimulates oxytocin release ***OR*** oxytocin release is an example of positive feedback; e. stimulates release of milk (from mammary glands);	*Award [max 2] if response only mentions one of the hormones.*	**3 max**

Question			Answers	Notes	Total
24.			a. red blood cells (RBC) play role in transport of both O_2 ***AND*** CO_2; b. RBC absorb O_2 **AND** release CO_2 in <u>alveoli</u>; *Oxygen* c. hemoglobin has (four subunits with) heme group/iron (ion) that carry/bind to oxygen; d. binding of oxygen to hemoglobin increases affinity of hemoglobin for oxygen; e. lower pH/more acidity/more H^+ decreases affinity of hemoglobin for oxygen; f. Bohr shift explains increased release of oxygen by hemoglobin in respiring tissues; *CO_2* g. CO_2 reacts with water (in RBC) to form H_2CO_3; h. H_2CO_3 dissociates into H^+ and HCO_3^-; i. (HCO_3^-) binds to hemoglobin/to form carboxyhemoglobin; j. higher acidity/lower pH/more H^+ results in the Bohr Shift;	*Accept points in correctly* ***annotated*** *diagrams.* *d. Accept cooperative binding.* *f. and j. Correct diagrams of Bohr shift have to be annotated for the marks*	**6 max**