6.034 Quiz 1

27 September 2017

Name	
Email	

For 1 extra credit point: Circle the TA whose recitations you attend, so that we can more easily enter your score in our records and return your quiz to you promptly:

Suri Bandler	**Erin Hong**	**Samarth Mohan**
Jake Barnwell	**Nathan Landman**	**Michael Shum**
Abigail Choe	**Amanda Liu**	**Jackie Xu**
Francesca Cicileo	**Nick Matthews**	

Problem number	Maximum	Score	Grader
1 - Search	35		
2 - Rules	35		
3 - Games	30		
Total	**100**		

There are 14 pages in this quiz, including this one, but not including tear-off sheets. A tear-off sheet with duplicate drawings and data is located after the final page of the quiz.

This quiz is open book, open notes, open just about everything, including a calculator, but no computers.

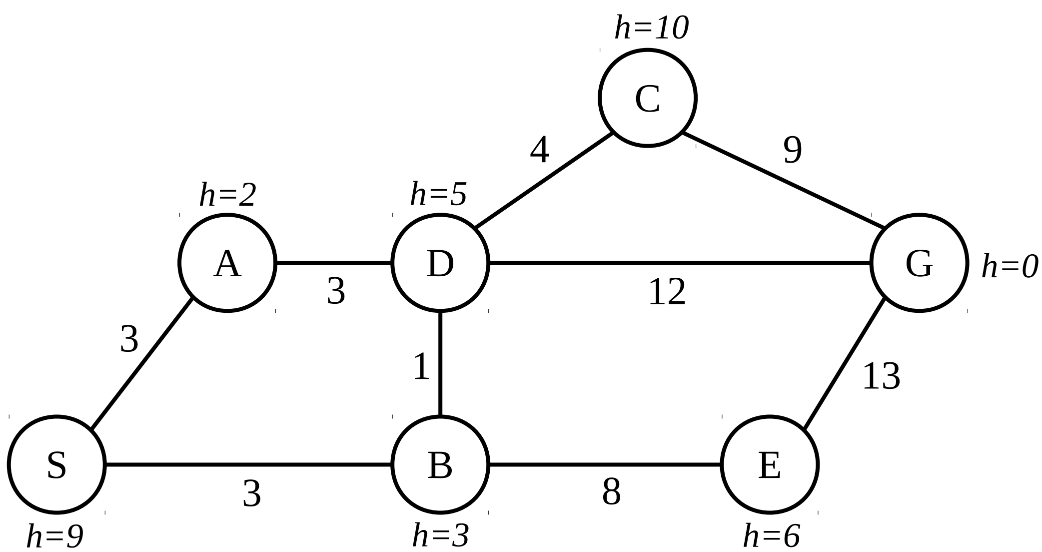
Problem 1: Search (35 points)

Part A: Finding Gazorpazorp (19 points)

Wanted criminal Rick Sanchez is on a quest to save his grandson from an alien corporation. Rick is currently on **S**hongi (**S** on the map), and his grandson is being held on the planet **G**azorpazorp (**G** on the map). Rick has estimates of how far it is from each location in the map to **G**.

For your convenience, a copy of this graph is provided on a tear-off sheet at the end of the quiz.

On the map below, numbers next to edges indicate edge lengths, and h *values next to nodes indicate Rick's heuristic estimates from the node to the goal.*



A1 (2 points) What is the shortest path from **S** to **G** in the graph above? (You may solve this problem by inspection. In case of a tie, prefer the path that comes first in dictionary order.) Write the shortest path, including nodes **S** and **G**, or write NONE if there are no paths between **S** and **G**.

A2 (9 points) As a first attempt, Rick decides to plan a trip from **S** to **G** using **hill-climbing search with <u>NO backtracking</u> and <u>NO extended set</u>**.

Below, draw the search tree that Rick will consider.

- Draw the children of each node in alphabetical order (e.g. A < B < C).
- Break any ties using dictionary order of the entire path (e.g. S-K-Y < S-P-A, because "SKY" appears before "SPA" in the English dictionary).
- Following lab convention, terminate your search when the path-to-goal is dequeued (popped) from the agenda.
- **Clearly indicate the order in which you dequeue (pop) nodes from the agenda** by numbering the dequeued nodes in your search tree (①, ②, ③, …).

*For credit, draw the search tree for **hill-climbing search** in the space below.*

A3 (2 points) What path did Rick find using **hill-climbing search** in part A2 above? (Write the path found, including nodes **S** and **G**, or write NONE if the search found no path.)

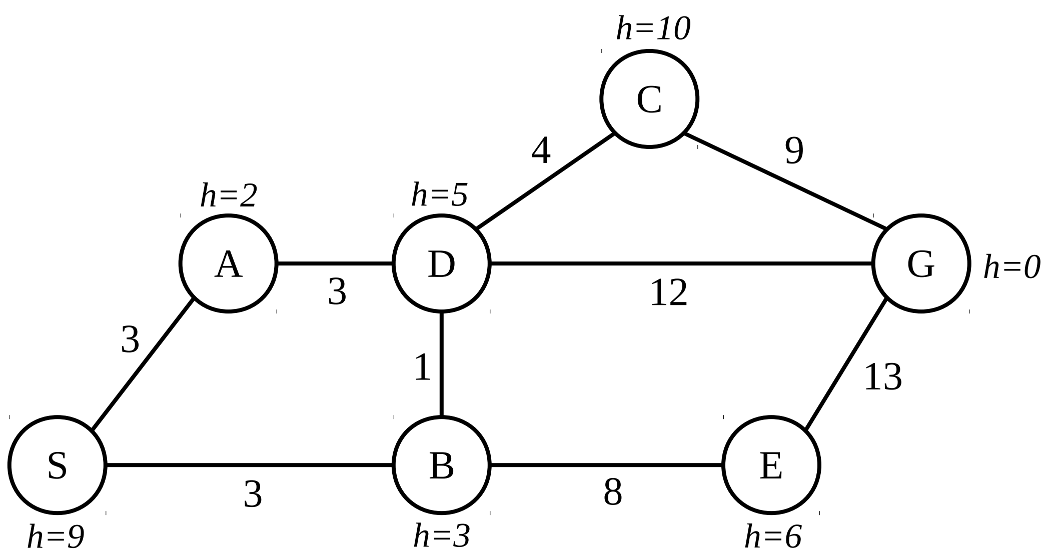
A4 (6 points) Rick suspects that the graph's heuristic may not be admissible. Which of the following nodes, if any, have heuristic estimates that **violate** the admissibility condition for heuristics? Circle all that apply. If NONE apply, instead circle NONE.

Node B **Node C** **Node D** **NONE**

Part B: The Truth Tortoise (16 points)

Rick is concerned that hill-climbing may not have found the shortest path. Fortunately, a Truth Tortoise reminds Rick that he can plan a trip using **A* search** instead.

For your convenience, the search graph has been duplicated below. It is also available on a tear-off sheet at the end of the quiz.



B1 (14 points) Rick now plans a path from **S** to **G** using **A* search** (branch and bound with extended set and heuristic).

On the next page, draw the search tree that Rick will consider.

- Draw the children of each node in alphabetical order (e.g. A < B < C).
- Break any ties using dictionary order of the entire path (e.g. S-K-Y < S-P-A, because "SKY" appears before "SPA" in the English dictionary).
- Following lab convention, terminate your search when the path-to-goal is dequeued (popped) from the agenda.
- **Clearly indicate the order in which you dequeue (pop) nodes from the agenda** by numbering the dequeued nodes in your search tree (①, ②, ③, …).

For credit, draw the search tree for ***A* search*** *in the space below.*

B2 (2 points) What is the path that Rick found using **A* search** in part B1 above? (Write the path found, including nodes S and G, or write NONE if the search found no path.)

Problem 2: Rule-Based Systems (35 points)

Part A: General Forward Chaining (12 points)

Brilliant adventurer Irene Adler is attempting to find flaws in Sherlock's logical deductions. Each of the following tables shows a few rounds of forward chaining on an unknown system of rules and assertions. For each table, determine whether the table could possibly be correct. If the table **could possibly** be correct, circle YES. If the table **could NOT possibly** be correct, circle NO and **briefly** explain why.

For these questions, make the following assumptions:

- Each part is **independent** of the other parts: the results from one table do not impact the results of any other tables.
- Rules are tried in the order they appear.
- Assertions are tried in the order they appear.
- **There are no NOT or DELETE clauses.**

A1 (4 points)

Iteration	Rules Matched	Rule Fired	New Assertion(s)
1	P0 P1	P1	*a*
2	P0 P1	P1	*b*

YES | **NO** (explain):

A2 (4 points)

Iteration	Rules Matched	Rule Fired	New Assertion(s)
927	P0 P1 P2 P3	P1	*p*, *q*
928	P0 P4	P0	*r*

YES | **NO** (explain):

A3 (4 points)

Iteration	Rules Matched	Rule Fired	New Assertion(s)
6033	P0 P1 P2 P3 P4	P3	*w*
6034	P0 P1 P2 P3 P4	P4	(None)

YES | **NO** (explain):

Part B: Backward Chaining (23 points)

After talking with Sherlock for five minutes, Moriarty suspects that Sherlock is a high-functioning sociopath. Being a smart villain, Moriarty gathers information through his secret organization and establishes the following rules and assertions.

For your convenience, a copy of these rules and assertions is provided on a tear-off sheet at the end of the quiz.

Rules:

P0	`IF AND( '(?y) thinks (?x) is unstable',`
	`         '(?y) is wrong' ),`
	`THEN '(?x) is not unstable'`

P1	`IF '(?x) is a high-functioning sociopath',` `THEN '(?x) solves crimes'`

P2	`IF AND( '(?x) has no friends',`
	`         '(?x) is not unstable' ),`
	`THEN '(?x) is a high-functioning sociopath'`

P3	`IF OR( AND( 'John gets married',`
	`             '(?y) thinks (?x) is unstable' ),`
	`        '(?x) has a skull' ),`
	`THEN '(?x) has no friends'`

P4	`IF '(?z) gets married',` `THEN '(?z) moves out of 221B'`

Assertions:

```
A0: 'Molly thinks Sherlock is unstable'
A1: 'Anderson is wrong'
A2: 'Sherlock has a skull'
A3: 'Anderson thinks Sherlock is unstable'
A4: 'John gets married'
```

B1 (19 points) Moriarty needs your help in determining whether or not Sherlock is indeed a high-functioning sociopath. Using the above rules and assertions, perform backward chaining starting from the hypothesis:

`'Sherlock is a high-functioning sociopath'`

Make the following assumptions about backward chaining:

- Rules are tried in the order they appear.
- Antecedents are tried in the order they appear.
- A hypothesis may match multiple assertions. Matches are tried in the order the assertions appear.
- AND and OR nodes are short-circuited (pruned) when possible.

In the table below, write all of the hypotheses that the backward chaining algorithm checks, **in the order they are checked**. (The first line has been filled in for you, and the table may have more lines than you need.)

You can show your work for possible partial credit:

- Use the space provided on the next page to draw the goal tree that would be created by backward chaining from this hypothesis.
- When backtracking variable bindings, indicate the new binding at every node.

Hypotheses checked in backward chaining:

H1. Sherlock is a high-functioning sociopath
H2.
H3.
H4.
H5.
H6.
H7.
H8.
H9.
H10.

Space provided to draw a goal tree (for possible partial credit).

Sherlock is a high-functioning sociopath

B2 (2 points) While doing backward chaining in part B1, how many times did you short circuit (if any), and how many times did you backtrack a set of variable bindings (if any)? Fill in each box below with a number (possibly 0).

I short-circuited [ ] times

I backtracked a set of variable bindings [ ] times

B3 (2 points) Does backward chaining prove the hypothesis **'Sherlock is a high-functioning sociopath'**? Circle YES or NO; or, if it's not possible to determine based on the information you're given, circle CAN'T TELL.

YES **NO** **CAN'T TELL**

Problem 3: Career Fair Planning (30 points)

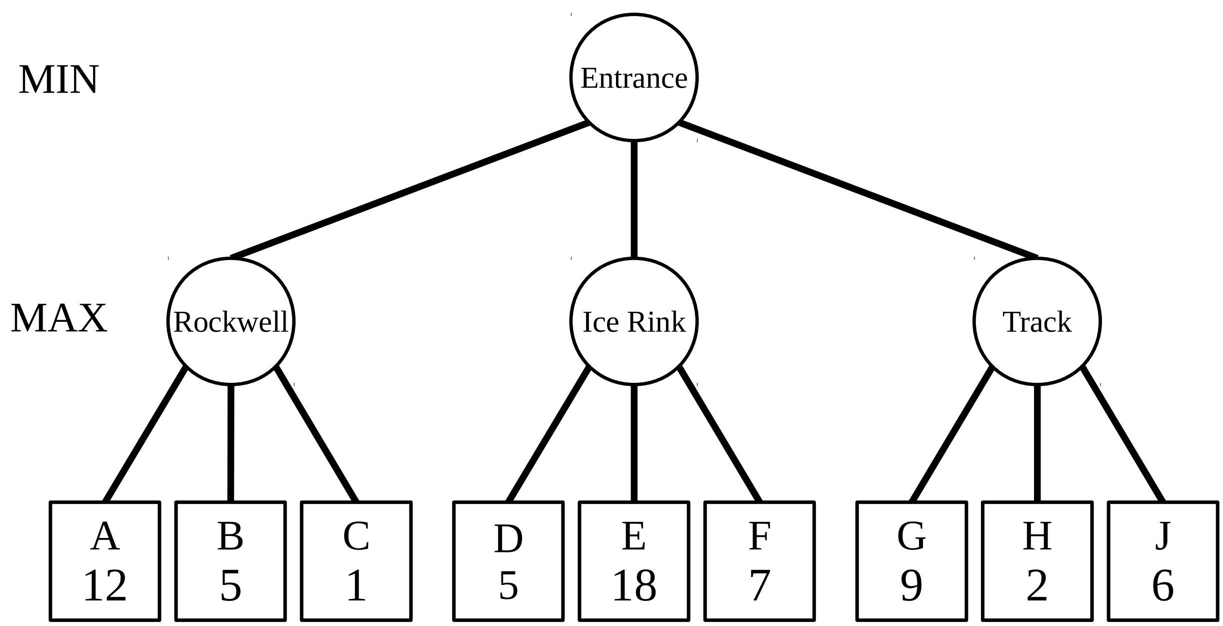
Part A: Career Fairness (15 points)

With Career Fair approaching, twins **<u>Min</u>**erva and **<u>Max</u>**well are planning on attending together! Maxwell wants to visit areas with lots of free T-shirts ("swag"), whereas Minerva would rather visit areas with minimal swag so that she can instead focus on meeting recruiters.

- Areas score **lower** if they have less swag, which is preferable for **Minerva**.
- Areas score **higher** if they have more swag, which is preferable for **Maxwell**.

Minerva has taken 6.034, and suggests that using the basic Minimax algorithm with no optimizations will allow them to find a good compromising path through the Career Fair.

For your convenience, a copy of this game tree is provided on a tear-off sheet at the end of the quiz.

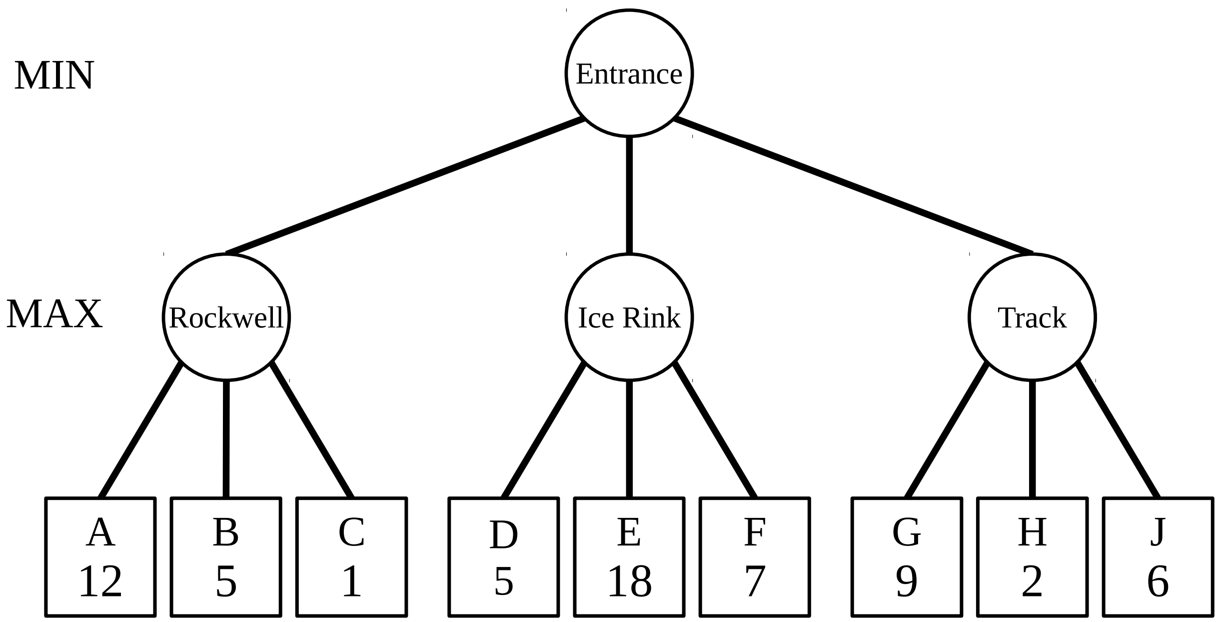


Keeping in mind that MIN moves first, what is the Minimax path that Minerva and Maxwell will take at the Career Fair? (For example, if the path they take terminates at node C, write "Entrance – Rockwell – C".) **For partial credit, write the Minimax score above each node in the tree above.**

Part B: Career Fairness—even faster (15 points)

Maxwell is surprised that it takes so long to perform Minimax, and asks Minerva if there is some way to speed up the process. Minerva recalls that there is an optimization to Minimax called alpha-beta pruning. Excited to review her 6.034 skills before the Career Fair, she redoes the Minimax search, employing alpha-beta pruning.

The tree below is identical to the tree in Part A.



Perform Minimax search <u>with alpha-beta pruning</u> on the tree above. Note that MIN moves first.

For possible partial credit, be sure to:

- Clearly show your work by annotating nodes as you perform Minimax with alpha-beta pruning. For example, at each node, you can list the values of alpha and beta as search progresses.
- For every leaf node that is **not** statically evaluated, draw a large **X** through it.
- Cross out branches that are pruned.

B1 (5 points) After performing Minimax search with alpha-beta pruning, what path do Minerva and Maxwell find? (For example, if the path they find terminates at node C, write "Entrance – Rockwell – C".)

B2 (7 points) Below,

- **CIRCLE** all leaf nodes that were statically evaluated during Minimax with alpha-beta pruning.
- **DRAW AN X** through all leaf nodes that were *not* statically evaluated during Minimax with alpha-beta pruning.

A	**B**	**C**	**D**	**E**
F	**G**	**H**	**J**	

B3 (3 points) Maxwell would rather visit booths with more swag. He asks Minerva to reorder some of the nodes in the tree and re-run Minimax search with alpha-beta pruning. Can Minerva **reorder the nodes under each parent** (preserving all parent-child relations) to **increase** the score of the path found by Minimax with alpha-beta pruning? (Note that Minerva can only *reorder* the nodes of the game tree; nothing else changes. MIN still moves first.)

- If so, circle YES and write one such possible score that can be attained.
- If not, circle NO and explain why it's not possible.
- If it can't be determined without more information, circle CAN'T TELL and explain what additional information Minerva needs.

YES ...and one such possible score is:

NO ...because:

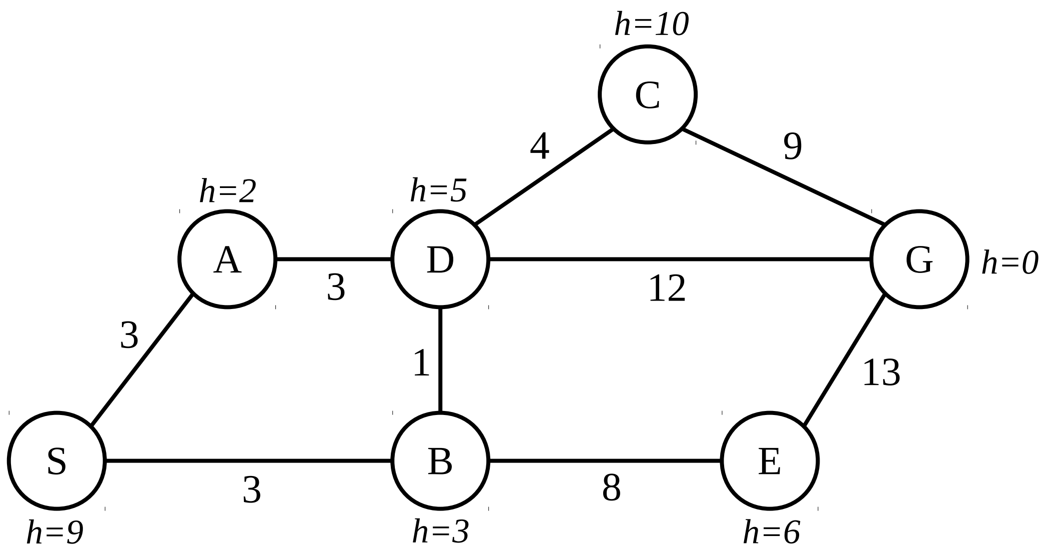
(15 words or fewer)

CAN'T TELL ...because:

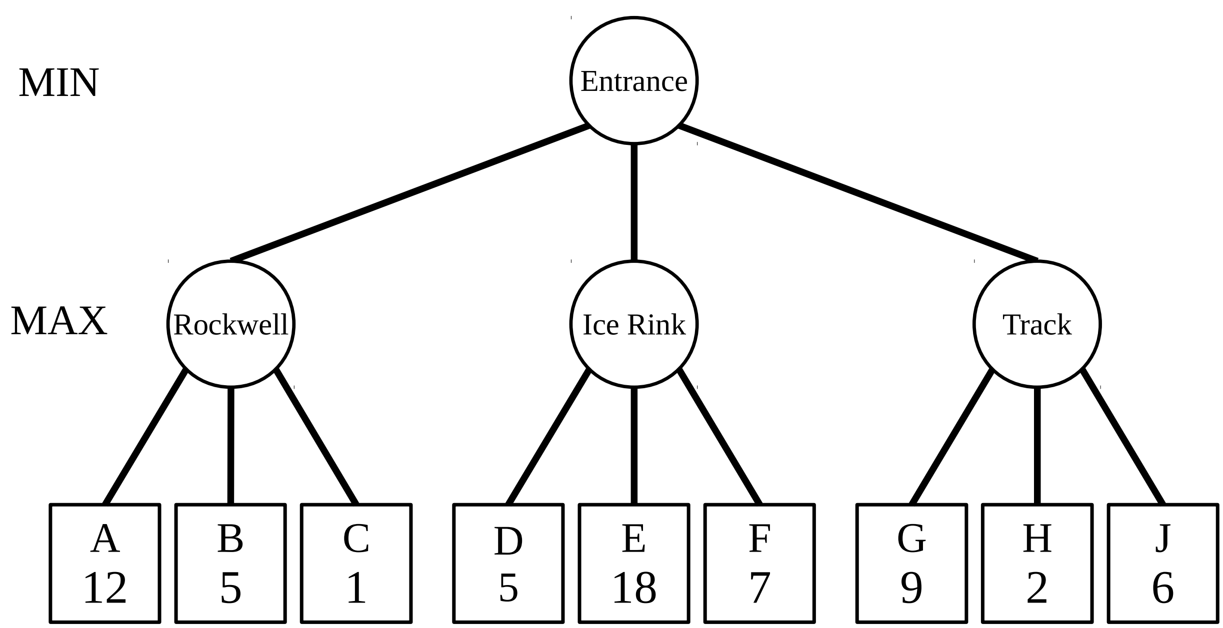
(15 words or fewer)

(Tear-off sheet)

Graph for Problem 1, Parts A & B



Game tree for Problem 3, Parts A & B



(Tear-off sheet)

Rules and assertions for Problem 2, Part B

Rules:

P0	IF AND('**(?y)** thinks **(?x)** is unstable', '**(?y)** is wrong'), THEN '**(?x)** is not unstable'
P1	IF '**(?x)** is a high-functioning sociopath', THEN '**(?x)** solves crimes'
P2	IF AND('**(?x)** has no friends', '**(?x)** is not unstable'), THEN '**(?x)** is a high-functioning sociopath'
P3	IF OR(AND('John gets married', '**(?y)** thinks **(?x)** is unstable'), '**(?x)** has a skull'), THEN '**(?x)** has no friends'
P4	IF '**(?z)** gets married', THEN '**(?z)** moves out of 221B'

Assertions:

```
A0: 'Molly thinks Sherlock is unstable'
A1: 'Anderson is wrong'
A2: 'Sherlock has a skull'
A3: 'Anderson thinks Sherlock is unstable'
A4: 'John gets married'
```